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Preface

Aquatic organisms in river basins in industrialised countries may be exposed to a large number of different contaminants. In many European countries fish and shellfish monitoring programmes are focused on priority pollutants. Usually, measured tissue residues are compared to consumption standards for human health protection. Hardly any information is available on potential ecological risks for predatory birds and mammals preying on contaminated fish and molluscs. Available data are limited to a selected number of black-list compounds, such as PCBs, DDT and related compounds, dioxins, and Hg.

Rijkswaterstaat RIZA and RIVO-DLO have conducted various studies on non-priority substances with accumulation potential. These studies were carried out in the framework of the "River Action Programs", the RIZA research program aimed to support the international commissions for the Rhine and Meuse.

In previous studies co-ordinated by J. Hendriks, and financed and conducted by the Institute for Inland Water Management and Waste Water Treatment (RIZA) and by the DLO-Netherlands Institute for Fisheries Research (RIVO), concentrations of substances were measured in mussel and eel sampled in the Rhine and Meuse.

In the current study an evaluation is presented on available knowledge with respect to less frequently studied contaminants, and on the possibility of extrapolating potential ecological risks from fish and shellfish residues. The study was commissioned by Rijkswaterstaat National Institute for Inland Water Management and Waste Water Treatment (RIZA) in the summer of 1997 (project KRITLIPO, contract no. RI-2245), and supervised by Dr. A.J. Hendriks and Mrs. Drs. M.A. Beek.

Many different persons have provided advice, information or publications at various stages of the current subproject project: Mrs Dr. A. Belfroid, Dr. F. Ariese and Mrs. D. Smit at IVM, R. de Vries and J. Zwetsloot of the Natural Sciences Library of de Vrije Universiteit (UBVU), Dr. P. de Voogt (MTC-UVA), Dr. T. Crommentuyn (RIVM), who are all acknowledged for their help.

The present report is an extended version (including the complete Annex-sections) of the results of the subproject on critical levels. An abbreviated version will be submitted as a paper to Chemosphere.

The integrated report combining both measurement studies and critical levels will be published by RIZA as a special publication in the series Ecological Rehabilitation of Rivers Rhine and Meuse (J. Hendriks, M. Beek, J. de Boer, B. van Hattum and H. Pieters (1998); Measured and critical concentrations of accumulative compounds in the Rhine-Meuse delta with emphasis on non-priority substances).

Contents

Summary

In the present study the occurrence and associated risks of approximately 40 individual contaminants (12 categories of compounds) in zebra mussels (*Dreissena polymorpha*) and eel (*Anguilla anguilla*) from the Rhine-Meuse estuary were evaluated. Most of the compounds are not included in existing priority lists or monitoring programs. A comparison was made with available literature data on ambient environmental levels and an attempt was made to assign specific background or reference levels. Different sets of critical levels were derived for the evaluation of direct toxic effects and of indirect secondary poisoning in fish and shellfish eating predators.

The relative contribution of compounds not regularly included in European monitoring programs, such as chlorobenzenes, phthalates, polychlorinated terphenyls (PCTs), toxaphene, tetrachlorobenzyltoluenes (TCBTs), polybrominated biphenyls (PBBs), polybrominated diphenylethers (PBDEs) and chlorinated nitrobenzenes, may range on a wet weight basis from approximately 3 to 10 % of the total organic micropollutant concentration (including e.g. PCBs, PAHs, DDTs, HCHs, drins and other chloro-biocides) in *Dreissena* and from circa 7 to 22 % in *Anguilla*.

In freshwater eel, PCTs and chlorobenzenes may be present in the range of 10 to 300 $\mu g \cdot kg^{-1}$ (wet weight), tris(4-chlorophenyl)methane, PBBs and PBDEs in the range 10-50 $\mu g \cdot kg^{-1}$, toxaphene in the range 12-20 $\mu g \cdot kg^{-1}$, and chlorobenzyltoluenes and chlorinated nitrobenzenes respectively in the range 1-7 $\mu g \cdot kg^{-1}$. Most of the compounds detected in zebra mussels and eel from the Rhine-Meuse estuary were present in concentrations well above levels reported for pristine areas, and comparable to levels reported for industrialised countries, but below levels reported for heavily polluted areas.

The total molar lipid-based concentrations of organic pollutant concentrations in eel and zebra mussels in the Rhine-Meuse basin are well below (at 0.003 - 0.2 %) the generic critical levels (40 - 160 $mmol \cdot kg^{-1}$ lipid wt) for direct chronic narcotic effects in fish and invertebrates. Relatively high total molar concentrations (especially of PAHs) were observed in zebra mussels from Eijsden in the River Meuse (at 0.7 - 3 % of critical levels), but this level is not likely to have induced chronic narcotic effects. The tissue residue concentrations in eel and mussels further indicated, that exposure levels of PCBs, DDT and y-HCH may have exceeded the NOEC levels for chronic effects in some sensitive fish species.

Biomagnification and food chain transfer is not believed to be of significance for most of the chlorophenols, chloronitrobenzenes and phthalates. A limited number of chronic NOECs for mortality, reproduction or growth could be identified for some chloro-phenols, toxaphene, chlordane, heptachlor, and several phthalates. Insufficient chronic toxicity data exist for PBBs, PBDEs, chloronitrobenzenes, tris(4-chlorophenyl)methanol (TCPMe), PCTs and TCBTs. A comparison with available generic critical levels for secondary poisoning revealed potential risks for DDT, heptachlorepoxid, and non- en mono-ortho substituted PCBs. The diet-based NOECs for sensitive predators such as mink, otter and the bald eagle were exceeded for total PCBs and toxic coplanar PCB congeners.

PBDE concentrations in eel are at 6 to 50% of a reported generic NOEC. Taking in to account corrections for lab-field differences in caloric content of prey- or food-items, this could probably mean that this NOEC may be exceeded in sensitive predators. Diet-based NOEC and other effect levels for chloronitrobenzenes, chlordane, toxaphene, phthalates suggest that additional risks of secondary poisoning due to exposure to these compounds probably will be negligible.

Human consumption standards for HCB in eel (50 $\mu g \cdot kg^{-1}$wet weight, Dutch standard) were exceeded at various locations. Non- and mono-ortho substituted PCB concentrations (expressed as dioxin equivalents) in eel from the Rhine (ΣTCDD-EQ: 0.026 $\mu g \cdot kg^{-1}$wet wt) and from the Hollands Diep (ΣTCDD-TEQ 0.116 $\mu g \cdot kg^{-1}$) are exceeding the 2,3,7,8-TCDD based Canadian standard (0.02 $\mu g \cdot kg^{-1}$wet wt).

1. Introduction

In most OECD countries contaminant related environmental policies are usually focused on priority pollutants. Priority pollutants and black-lists are an integral part of many international agreements (PARCOM, Rhine Action Plan, North Sea Action Plan). National and international monitoring programs are directed towards priority compounds such as e.g. toxic trace elements, PCB's, chlorinated pesticides, PAHs, dioxins. Ecotoxicological assessments of the environmental quality are usually based on these priority compounds.

Much less is known with respect to the ecological impact of non-priority compounds. Recent studies (Hendriks *et al.* 1998 chapter 2, Van Loon 1996) in the Rhine-Meuse basin have indicated that other, less frequently measured contaminants can be present in significant concentrations. Recent discoveries of new compounds of unknown origin (e.g. tris(4-chlorophenyl)methanol and tris(4-chlorophenyl)methane), in cetaceans and fish (Jarman *et al.* 1992, De Boer 1995), and the usually high unexplained fraction of unidentified organohalogen compounds in fish studies (Loganathan *et al.* 1995) demonstrate that the current approach still has many blank areas.

In most countries, environmental quality objectives for contaminants in aquatic ecosystems are defined as concentrations in abiotic environmental compartments (e.g. sediment and water) (BKH 1995). Usually they are not defined as maximum tolerable concentrations in sensitive predatory target species or prey-organisms. Especially for the protection of sensitive predatory species, this would be a preferable approach (Giesy et al 1994, Tillit *et al.* 1996, Smit *et al.* 1996). In the public health sector the derivation of ADI or TDI values (acceptable or tolerable daily intake in mg contaminant per kg body weight /day) from mammalian laboratory studies has a long tradition (see summary reports of joint FAO/WHO expert groups, such as e.g. IPCS(1996)) and is well accepted. In many countries this is used as a basis for human consumption standards of contaminants in food-products.

The potential risks of food chain transfer and secondary poisoning in sensitive predators (e.g. marine mammals, piscivorous birds) is steadily becoming accepted as an integral part of environmental risk assessment (Luttik 1992 and 1993, Hoffman *et al.* 1996, Nendza *et al.* 1997) and has served since the first half of the 1990s as a basis for quality objectives in various OECD countries, such as e.g. The Netherlands (Everts *et al.* 1993a 1993b, Van de Plasche *et al.* 1993, Romijn 1994) and the USA (Cook *et al.* 1993, US-EPA 1995). To date, this approach has been applied in different countries to a limited number of well known priority compounds, such as dioxins, PCB's, some chlorinated pesticides, Cd and Hg.

From many exotoxicological studies in the last decade it is well known that external exposure-concentrations are insufficient to fully explain the induction of toxic effects, and that species-specific toxicokinetic parameters should be taken into account. Internal exposure parameters (critical tissue residues, lethal body burden, LBB) usually provide a much better basis for the understanding of the variation in toxicity between chemical compounds and the differences in sensitivity among species (Deneer 1987, McCarty *et al.* 1993, Sijm 1993, Crommentuyn 1994, Van Wezel 1995).

Concentration levels in abiotic media (e.g. sediment or water column concentrations) seem to be of limited use as exposure parameters for evaluating the potential effects for organisms at higher trophic levels. Residue levels of contaminants in aquatic organisms are a result of a variety of processes, the most important of which are the partitioning between and within biotic and abiotic compartments, and simultaneous transformation reactions such as (bio)degradation, hydrolysis, photolysis and (bio)transformation (Karickhoff *et al.* 1979, DiToro *et al.* 1991, McCarthy and Mackay 1993). Some of these complex pathways and processes that determine the chemical fate of pollutants in aquatic ecosystems are indicated schematically in Fig.1 (adapted from Van Brummelen *et al.* 1997).

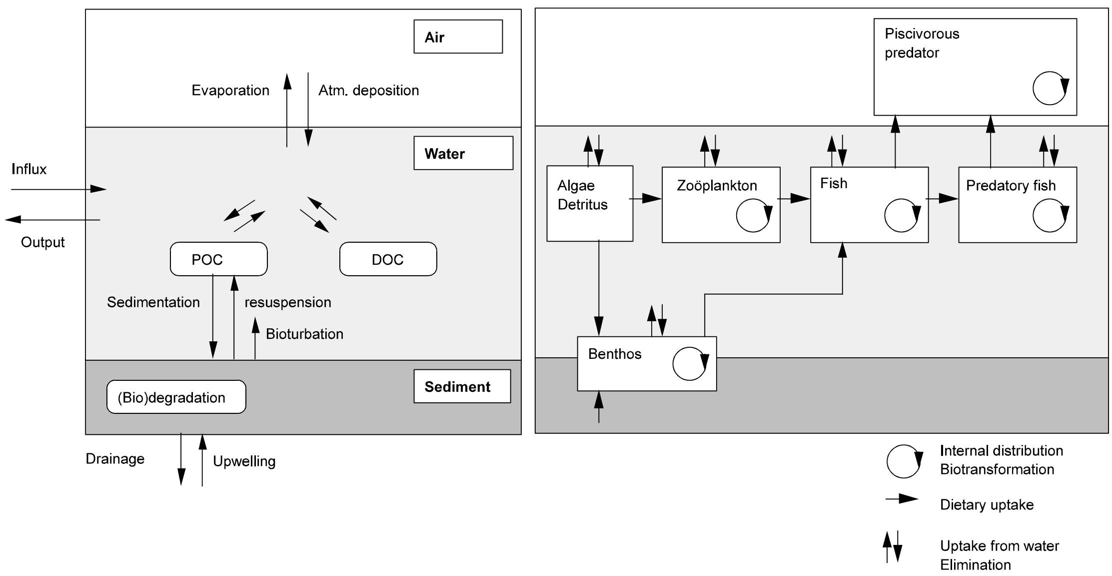

Figure 1. Schematic diagram of processes and mechanisms influencing tissue residues in aquatic organisms.

Tissue residues of molluscs and fish provide more direct information on the resulting net bio-availability in water systems, and are therefore expected to be more adequate for the evaluation of potential risks for organisms at higher trophic levels. As stated before, no internationally accepted framework for critical body burdens or maximum tolerable concentrations in prey organisms has been agreed upon yet, although for some priority compounds (dioxins, PCB, Hg) proposals can be found in the open literature. If such a framework could be developed, this would be of importance to environmental management, as this would offer the possibility to relate results from extensive exposure oriented monitoring programs (e.g. Mussel Watch projects, Joint Monitoring Program) to potential ecological risks.

2. Methods

In the present study an inventory was made of currently available data on occurrence, mammalian and avian toxicity, consumption standards, critical levels and other risk limits for a selected number of compounds, that were recently identified in zebra mussels and eel as part of regular monitoring programs in the Dutch Rhine-Meuse area. An attempt was made to evaluate the potency of these compounds for secondary poisoning in birds and mammals preying on fish and shellfish.

Data were obtained from literature and technical reports, retrieved with on-line searches in electronical databases (Chemical Abstracts, Biological Abstracts, Toxline, Aquatic & Fisheries Sciences, NTIS) available at different host organisations (Dialog and STN). As the evaluation of the quality of data in primary sources was beyond the scope of this study, use was made in many cases of secondary sources (reviews, criteria-documents, databases of qualified ecotoxicological data, such as AQUIRE). In the Annex section a more detailed description is given of the different searching strategies and the choices and selections made in the retrieval process. All data retrieved were included in a spreadsheet database presented in the Annex section, which is not reproduced in this report, but made available on request.

3. Results

Concentrations of categories of compounds observed in zebra mussels and eel in the preceding study of Hendriks *et al.* (1998) are summarised in Table 1. The concentrations observed for conventional priority pollutants (PAHs, PCBs, chlorinated biocides) are in line with results from similar studies in the area (Hendriks and Pieters 1993, IKSR 1993, De Boer 1995, Van Hattum *et al.* 1993). Expressed on a molar basis PAHs seem to be dominant in *Dreissena.* In eel especially PCB's are dominant, with significant contributions not only from well known chlorobiocides, such as p,p'-DDE and y-HCH, but surprisingly also from toxaphene and tris(4 chlorophenyl)methane.

Table 1. Concentration ranges (mmol·kg^{-1} lipid weight and µg·kg^{-1}wet weight) of organic micro pollutants in eel and zebra mussels from the Rhine-Meuse delta in 1994 (adapted from Hendriks et al. 1998, chapter 2).

Compounds	zebra mussel mmol·kg^{-1} fat weight	eel mmol·kg^{-1} fat weight	zebra mussel µg·kg^{-1} wet weight	eel µg·kg^{-1} wet weight
PAHs	0.02 - 1		36 - 3700	
PCBs	0.004 - 0.01	0.05 - 0.09	13 - 84	1380 - 2490
DDTs [a]	0.002 - 0.009	0.002 - 0.003	1 - 5	64 - 160
Drins [b]	0.0006 - 0.0008	0.0001 - 0.0002	0.3 - 0.6	5 - 11
HCHs [c]	0.00004 - 0.001	0.005 - 0.002	0.1 - 6	14 - 52
Toxaphene	0.0002 - 0.005	0.0003 - 0.0004	0.7 - 36	12 - 20
Chlordanes [d]	0.00004 - 0.0001	0.00002 - 0.00008	0.2 - 1.1	2 - 13
Heptachlors [e]	0.00003-0.00009	0.00005 - 0.0001	0.1 - 0.6	<1 - 4
Tris-4-chlorophenylmethane	n.d. - 0.0006	0.00003 - 0.002	n.d - 1.2	0.7 - 53
Chlorobenzenes [g]	0.0007 - 0.002	0. 002 - 0.006	1 - 7	53 - 220
Chloronitrobenzenes [h]	0.0002 - 0.0003	0.00006 - 0.0002	0.4 - 0.7	1 - 7
Polychlorinated terphenyls	0.0002	0.002 - 0.009	2	76 - 310
Phthalates [i]	0.001 - 0.003	0.00001	3 - 4	< 2 - 0.2
Chlorobenzyltoluenes [j]	0.0002 - 0.002	0.0002	0.7 - 9	<3 - 4
Bromobiphenyls [k]	0.00006 - 0.0004	0.0001 - 0.0007	< 0.15	1 - 30
Bromodiphenylethers [l]	0.00007 - 0.0005	0.0001-0.0005	0.3 - 4	6 - 46
Total organic micropollutants [m]	0.06 - 1.2	0.05 - 0.06	140 -3900	1900 - 3000

Locations: zebra mussels (Eijsden, Lobith and IJsselmeer), eel (Eijsden, Lobith (n=2) and Hollands Diep). Lipid content: zebra mussels 1-2 %, eel 9-18 %. [a]sum of 4,4' substituted DDT, DDE and DDD, [b]aldrin and endrin, [c]including α-HCH, β-HCH and γ-HCH, [d]incl. cis-chlordane, trans-chlordane, cis-chlordene, trans-chlordene, oxychlordane, transnonachlor, [e]incl. alpha- and beta- isomers of heptachlor and heptachlorepoxide, [f]Sum of DDTs, endosulfan, HCHs, drins, heptachlors, hexachlorobutadiene, toxaphene, chlordanes, [g]incl. 8 tri-, tetra,- penta- and hexa- substituted congeners, [h]sum of 7 mono- and dichloro substituted nitrobenzenes, [i] incl. dimethyl- and diethylphthalates, dioctyl- and di-2-ethyl-hexylphthalates had high detection limits, [j]tetrachlorobenzyltoluenes, [k] sum of 6 tetra-, penta- or hexabromo substituted congeners, due to analytical difficulties, the precision of the results is limited, [l]tetra- and pentabromo substituted congener, [m]range of mean cumulative values at 3 - 4 locations.

The contribution of compounds not regularly included in monitoring programs (compared to total organic micropollutant concentrations) ranges on a wet weight basis from approximately 3 to 10 % (contribution of chlorophenols excluded) in *Dreissena* and from circa 7 to 22 % in *Anguilla*. In zebra mussels compound categories such as chlorobenzenes, phthalates, polychlorinated terphenyls, chlorobenzyltoluenes and brominated biphenyls or diphenylethers may contribute each at concentration levels of 1-10 $\mu g \cdot kg^{-1}$wet weight. In eel, polychlorinated terphenyls and chlorobenzenes may be present in the range of 10 to 300 $\mu g \cdot kg^{-1}$(wet weight), tris(4-chlorophenyl)methane, bromobiphenyls and bromodiphenylethers in the range 10-50 $\mu g \cdot kg^{-1}$, and chlorobenzyltoluenes and chlorinated nitrobenzenes respectively in the range 1-7 $\mu g \cdot kg^{-1}$wet weight. The contribution of toxaphene, which usually is not included in Dutch or European monitoring programs, varies from 1-36 $\mu g \cdot kg^{-1}$in zebra mussels and 12-20 $\mu g \cdot kg^{-1}$in eel. This confirms previous findings of Zell and Ballschmiter (1980) in Alpine lakes, and that significant amounts of this compound may be present in European river basins. As this first generation pesticide has hardly been applied in western Europe, the occurrence of this compound in European waters usually is attributed to atmospheric transport from the North American continent (De Boer 1995, Saleh 1991).

3.1 Concentrations in other areas

In Table 2 and Table 3 short summaries are presented for compounds that are not usually included in European fish or shellfish monitoring studies. Details of the studies cited are included in the tables in the Annex section. For toxaphene and chlordane extensive material is available for comparison, especially from N. American studies. These two groups of compounds were included in the US National Status and Trend Mussel Watch Program (Sericano *et al.* 1993) and the US National Pesticide Monitoring Program (Schmitt *et al.* 1985). For the other compounds the number of available studies for reference is much more limited.

Comparisons between different studies may be complicated by differences in species, tissues or organs analysed (e.g. muscle, liver) or the weight basis used for reporting the results (wet weight, lipid weight, dry weight). Further complications may stem from discrepancies in analytical methodologies (e.g. packed column GC with non-specific ECD/FID detection in older studies until the 2nd half of the 1980s, versus high resolution capillary column GC-MS in more recent studies). Especially for complex mixtures such as toxaphene, chlordane related compounds, polychlorinated terphenyls and chlorinated benzyltoluenes the nomenclature, identification and quantification of specific individual compounds still has not yet been fully resolved (Muir and De Boer 1995, Lauenstein 1995, Wester *et al.* 1997a 1997b).

Table 2. Summary of literature data on selected contaminants in fish[a].

Compound - Species	Location	Year	Conc.	Unit	Ref.
Brominated biphenyls					
- whitefish.	Lake Storvindeln (S)	1986	0.29	$\mu g \cdot kg^{-1}$lw	Jansson e.a. 93
- fish var. species	13 rivers , lakes (USA)	74-83	<.3-1300	$g \cdot kg^{-1}$ww	IPCS (1994)
Brominated di-phenylethers					
- whitefish	Lake Storvindeln (S)	1986	26	$\mu g \cdot kg^{-1}$lw	Jansson e.a. '93
- carp	Buffalo River (USA)	1991	22	$\mu g \cdot kg^{-1}$ww	Loganath. e.a. '95
- fish var. sp.	Rivers Germany	< 88	0.6 - 120	$\mu g \cdot kg^{-1}$lw	Krüger et al (1988)
Chlorophenols					
- whitefish	Lake Storvindeln (S)	1986	< 140	$\mu g \cdot kg^{-1}$lw	Jansson e.a. '93
- Trachurus novaezelandiae	Sydney coast (Austr)	1993	< 0.5	$\mu g \cdot kg^{-1}$ww	Jennings e.a. '96
Toxaphene					
- freshwater fish	107 lakes, rivers (USA)	'80-'81	0.3 - 21	$mg \cdot kg^{-1}$ww	Schmitt e.a. '85
- burbot (liver)	8 remote lakes Canada	'85-'86	0.8 - 2.3	$mg \cdot kg^{-1}$lw	Muir e.a. '90
- eel	Great Lakes	<'93	0.13	$mg \cdot kg^{-1}$ww	Newsome and Andrews (1993)
- lake trout	Great Lakes	'92-'93	0.1 - 7	$mg \cdot kg^{-1}$ww	Glassmeyer ea'97
- marine species	Antarctica	<1980	<100	$\mu g \cdot kg^{-1}$lw	in Wania e.a. '93
- freshwater fish.	Swedish Lakes	.71-80	0.4 - 13	$mg \cdot kg^{-1}$lw	Andersson e.a.'88
Chlordanes					
- whitefish	Lake Storvindeln (S)	1986	19	$\mu g \cdot kg^{-1}$lw	Jansson e.a. '93
- perch	Great Lakes (USA)	1990	2 - 26	$\mu g \cdot kg^{-1}$ww	Giesy e.a. '94
- burbot (liver)	8 remote lakes Canada	'85-'86	140-380	$\mu g \cdot kg^{-1}$lw	Muir e.a. '90
- freshw. fish	5 remote lakes (USA)	<'85	<10-1000	$\mu g \cdot kg^{-1}$lw	in Muir e.a. '90
- eel	St. Lawrence Riv. Can)	1990	20-70	$\mu g \cdot kg^{-1}$ww	Hodson e.a. '93
- hake sp., flying fish	Falkland isles	1988	0.1	$\mu g \cdot kg^{-1}$ww	De Boer '95
Polychlorinated terphenyls					
- mummichog	Tabs Creek (USA)	1989	<0.1 - 7	$mg \cdot kg^{-1}$dw	Gallagher e.a. '93
- marine fish	Japan Sea	< '79	0.01	$mg \cdot kg^{-1}$ww	Takai e.a. '79
- eel	Baltic Sea	< '78	0.08	$mg \cdot kg^{-1}$ww	Renberg e.a. '78
Tetrachlorobenzyltoluenes					
- freshw. fish	Lippe, Ruhr	1987	<0.3-110	$mg \cdot kg^{-1}$lw	Friege e.a. '89
- feshw. fish	Weser, upstream areas Lippe and Ruhr (Germany)	<'87	20	$\mu g \cdot kg^{-1}$ww	Fürst e.a. '87
- eel	remote Lakes Netherlands	1989	<40	$\mu g \cdot kg^{-1}$ww	De Boer '95
Phthalates					
- marine fish	Gulf St. Lawrence (Can)	1978	4 - 7	$mg \cdot kg^{-1}$ww	Musial e.a. '81
- dab liver	Crouch estuary (UK)	< 83	23	$\mu g \cdot kg^{-1}$ww	Waldock '83

[a] Selection of most relevant studies, full data are provided in Annex A.9; lw = lipid weight, ww = wet weight.

Table 3. Synopsis of bivalve and other invertebrate studies - review of literature data on selected compounds.[a]

Compound - Species	Location	Year	Conc.	Unit	Ref.
Brominated biphenyls					
- M. edulis	Osaka Bay (Japan)	< 87	15	$\mu g \cdot kg^{-1}$ww	Watanabe e.a. 87
Brominated diphenylethers					
- mussel	Osaka Bay (Japan)	< 87	2 - 14	$\mu g \cdot kg^{-1}$ww	Watanabe e.a. 87
- mussel	other coastal waters	< 87	< 0.3	$\mu g \cdot kg^{-1}$ww	Watanabe e.a. 87
Chlorophenols					
- M. edulis	Sydney Coast (Australia)	1993	< 0.5	$\mu g \cdot kg^{-1}$ww	Jennings e.a. '93
- M. edulis	Danish coast	< '86	0.2 - 3	$\mu g \cdot kg^{-1}$ww	Folke e.a. '86
Tri-chlorophenylmethane related compounds					
M. edulis					De. Boer e.a.
- TCPMe	Wadden Sea (NL)	1994	< 6	$\mu g \cdot kg^{-1}$lw	(1987)
- TCPMeOH	Wadden Sea (NL)	1994	13	$\mu g \cdot kg^{-1}$lw	De. Boer e.a. (1987)
Toxaphene					
- amphipods	A. Heidelberg Island (Can)	'86-'87	440-1730	$\mu g \cdot kg^{-1}$dw	Bidleman e.a. '89
- amphipods	L. Michigan (USA)	1982	470	$\mu g \cdot kg^{-1}$dw	Evans e.a. '91
- zooplankton	L. Laberke (Yukon, Can)	<96	4	$\mu g \cdot kg^{-1}$ww	Muir e.a. '97
Chlordanes					
- oysters	Gulf of Mexico (USA), n=140	86-90	15-29	$\mu g \cdot kg^{-1}$dw	Sericano e.a. '93
- bivalves	US Coast (USA), n=51	1977	19	$\mu g \cdot kg^{-1}$ww	Lauenstein '95
		1992	6		
- bivalves	Coast South America,n=76	'91-'92	<1 -10	$\mu g \cdot kg^{-1}$dw	Sericano e.a..'95
- zooplankton	Ontario (Can), 33 lakes	1986	0.7 - 22	$\mu g \cdot kg^{-1}$dw	Taylor e.a.'91
Heptachlors					
- oysters	Gulf of Mexico (USA), n=140	86-90	2 - 4	$\mu g \cdot kg^{-1}$dw	Sericano e.a. '93
Nonachlors					
- oysters	Gulf of Mexico (USA), n=140	86-90	5 - 12	$\mu g \cdot kg^{-1}$dw	Sericano e.a. '93
Polychlorinated terphenyls					
- Am. oyster	Tabs Creek (USA)	1989	2 - 18	$mg \cdot kg^{-1}$dw	Gallagher e.a. '93
- Am. oyster	Rappahannock R. (USA)	1989	< 0.1	$mg \cdot kg^{-1}$dw	Gallagher e.a. '93
Phthalates					
- clams	Portland Maine (USA)	< '83	nd - 170	$ng \cdot kg^{-1}$ww	Ray e.a. '83
- invertebrates	Lakes Finland	< 86	5 - 14	$mg \cdot kg^{-1}$ww	Thuren '86
- bivalves dig. gland	Crouch estuary (UK)	< 83	10	$\mu g \cdot kg^{-1}$ww	Waldock '83

[a] Selection of most relevant studies, full data are provided in Annex A.10.

For some compound classes, only a limited number of studies could be traced (bromobiphenyls, bromodiphenylethers, Chlorophenols, polychlorinated terphenyls, tetrachlorobenzyltoluenes and phthalates) or a limited number of individual compounds or congeners was analysed. For other compounds (e.g. chloronitrobenzenes) no data at all could be retrieved on levels in biota. In Table 4 and Table 5 an indication is given of concentrations that could be considered as representative for background concentrations. This was based on measurements in remote and pristine areas, or on the lower range of observations from large surveys or monitoring programs. As several persistent compounds (HCHs, Toxaphene, PCBs, DDT) may undergo long-range transport and selective deposition or condensation in remote areas (Wania and Mackay 1993a and 1993b) many previously pristine environments are influenced by past and present emissions in agricultural and industrialised regions.

Table 4. Tentative indication of background-concentrations in fish, based on lowest reported levels for remote or pristine locations.

Compound	[a]conc. µg·kg^{-1} wet weight	species, location	references
- PBBs	< 0.02	salmonid Lake Storvindeln, Lapland	Jansson e.a. '93, IPCS '94, Pijnenburg e.a. '95
- PBDE's	< 0.2	salmonid Lake Storvindeln, Lapland	IPCS '94, Jansson e.a. '93
- Chlorophenols	< 1	salmonid Lake Storvindeln, Lapland, marine sp., Sydney Coast, Australia	Jansson e.a. '93, Jennings '93
- Toxaphene	<5 <10	dab, sole, angler, pollack, bass Southern North Sea Antarctica [b]	De Boer '95, cit. in Wania e.a. '93
- Chlordanes (total)	< 0.2	salmonid, Lake Storvindeln, Lapland, marine fish, Falkland isles	Jansson e.a. '93, De Boer '95
- Heptachlors	< 0.1	marine fish, Falkland isles	De Boer '95
- Nonachlors	< 0.2	marine fish, Falkland isles	De Boer '95
- TCBTs	<20 <40	upstream areas German Rivers, eel (10-20 % lipid) remote lakes Netherlands	Fürst e.a. '87, Friege e.a. '89., De Boer '95
- PCTs	<10	marine fish, Japan Sea	Takai e.a. '79
- Phthalates	<10	dab, Crouch estuary (UK)	Waldock '83

[a] low lipid fish (< 5 %) were chosen, unless otherwise indicated, [b] 10% lipid assumed.

Table 5. Tentative indication of background concentrations in bivalves, based on lowest reported levels.

Compound	conc. µg·kg^{-1} wet weight	species, location	references
PBBs	< 1	mussel, coastal waters, Japan.	Watanabe e.a. 87, IPCS '94, Pijnenburg e.a. '95
PBDE's	< 0.3	mussel, coastal waters Japan.	Watanabe e.a. '87, IPCS '94, Janson e.a. '93
Chlorophenols	< 0.5	mussel, Danish coast, Sydney Coast, Australia	Folke e.a. 86, Jennings '93
Toxaphene	< 5	invertebrates, Lake Laberge (Can.)	Muir e.a. '97
Chlordanes (total)	< 0.2	mussel, oysters Gulf of Mexico, coastal waters Central South America[a]	Sericano e.a. '93 and '95
Heptachlors	< 0.2	Gulf of Mexico [a]	Sericano e.a. '93
Nonachlors	< 0.2	Gulf of Mexico [a]	Sericano e.a. '93
PCTs	< 20	Rappahannock river USA	Gallagher e.a. '93
Phthalates	< 5	bivalves, Crouch estuary (UK) [b]	Waldock '83

[a] Lowest 10% of values from Mussel Watch data, dry wt of 20% assumed for conversion, [b]Ratio of 2:1 assumed for concentrations in digestive gland versus muscle

Another factor, complicating the assignment of background concentrations, is the fact that for several compounds only data are present from problem or incident oriented studies, i.e. in exposed environments influenced by direct emissions. This is the case for e.g. chlorophenols, polychlorinated terphenyls, tetrachlorobenzyltoluenes and phthalates.

In the American part of the Northern hemisphere relatively high concentrations of toxaphene can be found even in remote arctic lakes and rivers, due to atmospheric deposition (Muir *et al.* (1990). Data summarised by De Boer (1997) indicate that relatively high toxaphene concentrations can be found in various European habitats, even in remote lakes in Switzerland. As this compound has hardly been applied in western European countries, atmospheric transport is assumed to be the most likely cause. The concentrations of toxaphene in eel and zebra mussels from the Rhine-Meuse basin (1 - 20 $\mu g \cdot kg^{-1}$ wet weight) are above background levels (5 $\mu g \cdot kg^{-1}$ wet weight) but far below the levels observed in North American and Canadian studies (usually ranging from 100 - 21,000 $\mu g \cdot kg^{-1}$ wet weight). The number of European freshwater studies on toxaphene is limited, especially for invertebrate species.

A similar finding is noted for chlordane related compounds. Chlordane has not been used on a large scale in Europe and only a limited number of relevant European studies was traced. Similarly as with toxaphene (Muir and De Boer 1995, Buser and Müller 1993), the analytical methodology of chlordanes is complicated. The concentrations in zebra mussels (0.2 - 1.1 $\mu g \cdot kg^{-1}$ wet weight) are just above background levels derived from the N. American Mussel Watch studies (Sericano *et al.* 1993) . The concentrations in eel (2 - 13 $\mu g \cdot kg^{-1}$ wet weight) are above the values from pristine areas (Lapland, Falkland Isles), but well below levels observed in North American rivers and waters in industrialised areas (St. Lawrence river) or systems in arctic areas.

Brominated compounds are present in the Rhine-Meuse area (<0.1 - 46 $\mu g \cdot kg^{-1}$ wet weight) in levels exceeding background concentrations (< 0.02 - 1 $\mu g \cdot kg^{-1}$ wet weight) observed in Japan and an arctic lake in Lapland. The concentrations are comparable to levels observed in other industrialised countries, but well below the sometimes high levels in N. American studies in areas affected by accidental emissions or deposition of waste incineration (IPCS 1994). Recent Dutch studies (De Boer 1995, Pijnenburg *et al.* 1995, Boon et al 1997) have demonstrated that relatively high levels may occur in marine mammals and cormorants, and that these compounds are likely to be biomagnified in food chains.

The observed concentrations of tris(4-chlorophenyl)methane in eel (1-53 $\mu g \cdot kg^{-1}$ wet weight) are comparable to levels encountered for individual DDT-related compounds. Available data for comparison are restricted mainly to marine species, and have been reviewed by De Boer (1997). In this and other studies (Jarman *et al.* 1992) a significant biomagnification was demonstrated. The available knowledge on sources (Buser 1995, De Boer *et al.* 1996), environmental behaviour and toxicity of TCPMe and TCPM is limited.

For chlorophenol the analytical difficulties (Jansson *et al.* 1993) probably have limited the number of available studies for comparison. Although the reliability of the concentration data for zebra mussels is limited, due to variability and low recovery (Hendriks *et al.*, 1998), the observed values (70 - 100 $\mu g \cdot kg^{-1}$ wet weight, not indicated in Table 1) are well above the levels (< 0.5 $\mu g \cdot kg^{-1}$ wet weight) reported by Folke *et al.* (1986) and Jennings *et al.* (1993) for bivalves in coastal waters in Denmark and Australia. This indicates that a significant exposure to these compounds may occur in the Rhine-Meuse basin.

In conclusion, the less conventional pollutants considered in this study may constitute 3 to 22 % of the total concentration of organic microcontaminants in eel and zebra mussels. The concentration levels in the Rhine-Meuse basin are comparable to levels observed in other industrialised countries, but well below concentrations reported for heavily polluted areas.

3.2 Concentrations in toxicity studies with fish and invertebrates

The extent, to which observed mollusc or fish tissue residues in monitoring studies can be related to ecological risks, is still limited. A distinction can be made between direct effects in the fish or mollusc species or the indirect effects at higher trophic levels (secondary poisoning).

3.2.1 Critical body residues determined experimentally

From experimental studies (Donkin *et al.* 1989, McCarty *et al.* 1993, Sijm *et al.* 1993, Crommentuyn *et al.* 1994, Van Wezel *et al.* 1995a 1995b,1995c) the so-called LBB (lethal body burden) or CBR (critical body residue) framework has been developed, explaining kinetics and dynamics of toxic effects, such as (polar) narcosis. For a large variety of chemicals and organisms the internal exposure level above which specific toxic effects may occur is relatively constant. The well known (QSAR) inverse relationships between the hydrophobicity of chemicals and its toxicity endpoints (LC50, EC50) can be explained within the LBB/CBR framework as the result of differences in bioconcentration (McCarty and Mackay 1993). A brief selection of CBR levels for different modes of action reviewed by McCarty and Mackay (1993) and Van Wezel (1995) is presented in Table 6.

To date, the use of the LBB/CBR concept has been limited mostly to experimental toxicity studies and risk assessments for compounds for which toxicity data are lacking. Its application in monitoring studies has been limited up to now, as (except for the dioxin-like effects) most of the above mentioned modes of action and effects are typical for high-exposure situations, which usually exceed by far the conditions in the field.

Additionally, the LBB/CBR approach offers the possibility of analysing the total toxic effects of compounds with additive modes of action, without taking into account environmental and species-specific factors influencing bio-availability and toxicokinetic. For narcosis and polar narcosis such an additivity has been demonstrated for many compounds (Van Wezel 1995). As the total number of compounds, that is usually measured in monitoring programs (10 - 100) or for which environmental standards exist, is usually limited compared to the total number of chemicals to which organisms may be exposed in the field, this approach may provide information on the contribution of many unknown chemicals to baseline narcotic risks. Van Wezel (1995) compared measured concentrations of micropollutants in mussels (*Mytilus edulis*) with a generalised LBB-level for chronic narcotic effects of 0.5 mmol·kg^{-1} wet weight (40 - 160 mmol·kg^{-1} lipid weight) and concluded that total residues in mussels from PAHs, PCBs and chlorinated pesticides (0.4 - 0.5 mmol·kg^{-1} wet weight, 16 - 39 mmol·kg^{-1} fat weight) from the Scheldt estuary (Western Scheldt) were approaching critical levels, and that adverse effects might be expected.

Table 6. Selection of critical body residue levels in fish and invertebrates for different modes of toxic action reviewed by McCarty and Mackay (1993) and Van Wezel et al. (1995).

Chemical/effect	estimated CBR mmol·kg^{-1} wet weight	Remarks, examples
Narcosis		
- acute	2 - 9	halobenzenes, PCBs, pyrene
- chronic	0.2 - 0.8	
Polar narcosis		
- acute	0.6 - 1.9	(chloro)anilines, phenols
- chronic	0.2 - 0.7	trichlorophenols
AChE-inhibition		
- acute	0.05 - 2	e.g. malathion, chlorpyrifos
- chronic	0.003	chlorpyrifos
Respiratory blocking		
- acute	0.0006 - .0.003	rotenone
TCDD-like (dioxins)		
- growth, survival	3 - 80 . 10^{-6}	
- early life stage - NOAEL	1 - 2. 10^{-7}	

The total molar lipid-based concentrations of organic concentrations in eel in the Rhine-Meuse basin are well below (at 0.003 - 0.1 %) of the critical levels (40 - 160 mmol·kg^{-1} lipid wt) for chronic narcotic effects. The induction of such effects in eel is not likely. The molar concentrations in zebra mussels are at similar levels in Lake IJsselmeer and the River Rhine (at 0.003 - 0.2 %). In the zebra mussels from Eijsden in the River Meuse (1.2 mmol·kg^{-1} lipid wt) the critical level for chronic effects is approached at 0.7 - 3 %), due to the high PAHs concentrations, but the induction of chronic narcotic effects in bivalves is not very likely.

3.2.2 Critical body residues extrapolated with bioaccumulation factors

Other related approaches to derive critical tissue residues in fish from experimental fish toxicity and bioconcentration data have been followed by Hendriks (1995), Beek (1995) and Nendza *et al.* (1997). Extrapolated aqueous no observed effect concentrations (lowest reported NOEC in e.g. µg/L) were combined with bioconcentration data (BCF in L/kg) to estimate provisional compound specific CBBs (critical body burden, CBB = NOEC x BCF), which in turn were be compared to data from marine fish monitoring studies. As an example the CBBs estimated by Nendza *et al.* (1997) are summarised in Table 9, underlying data are presented in Annex 11.1. Based on tissue residues in marine fish from the North Sea absence of effects (tissue residues < 1% of CBB) was proposed for hexachlorobenzene and dieldrin, potential contributions to joint toxicity was proposed for pentachlorophenol and chloroparaffins (tissue residues 1-10% of CBB), and direct impact (tissue residues > 10% of CBB) was assumed for: DDT, lindane, fluoranthene, PCBs, mercury, benzo[a]pyrene and cadmium (Nendza *et al.* 1997). The method is limited to compounds that do not undergo biotransformation. Using this approach, the no-effect CBBs for chronic toxicity in sensitive fish-species are exceeded at one or more locations PCBs, DDT, and HCH.

Beek (1995) and Hendriks (1995) related critical exposure levels for sensitive aquatic organisms (e.g. algae, invertebrates, fish) to equivalent tissue-residues in fish and bivalves. Aquatic ecosystem-based maximum permissible concentrations (MPCs for water, suspended matter and sediments), based on systematic evaluations of the toxicity to different taxa and safety-factors based on the uncertainty of the underlying data (Van der Plassche *et al.* 1993, Romijn *et al.* 1993, Kalf *et al.* 1997), are converted with bioconcentration data (BCFs) to equivalent levels in bivalves and fish. This approach is currently being used as an additional interpretation framework in Dutch water quality assessments. Again, this approach only holds for compounds that are not subject to biotransformation.

3.3 Concentrations in dietary toxicity studies with birds and mammals

Indirect effects may result from trophic transfer and biomagnification of contaminants. High concentrations of persistent lipophilic compounds (e.g. PCBs, DDT, mirex, toxaphene) have been reported in marine mammals and piscivorous birds from all over the world (Anderson et al 1988, De Boer *et al.* 1994, 1997, Hoffman *et al.* 1996, Jansson *et al.* 1993, Jarman *et al.* 1992, Macdonald and Bewers 1996, Muir *et al.* 1995 1996, Giesy *et al.* 1994 1995, Vetter *et al.* 1996, Suedel *et al.* 1994, Falandysz *et al.* 1996). Our current understanding of the extent and magnitude of these effects is still limited.

Only for dioxins and PCBs diet-based risk limits (for contaminant concentrations in prey items) have been derived from more extensive field- and laboratory studies for a limited number of predatory species, such as mink (Giesy *et al.* 1994, Leonards 1994, Tillet *et al.* 1996), otter (Leonards 1997, Smit *et al.* 1996), bald eagle (Giesy *et al.* 1995) or herring gull (Braune and Norstrom 1989). In these studies an eco-epidemiological approach was followed, in which cause-effect linkages were resolved and biomagnification and diet- and internal concentration-based effect models were developed. In Annex A.11.3 some of the diet-based critical levels are summarised.

For most compounds the potential for secondary poisoning has to be inferred from physico-chemical and compound-specific properties, toxicokinetics, and mammalian and avian laboratory experiments. Determinants of the potency for biomagnification and secondary poisoning of compounds include: persistence and bio-availability in the abiotic environment, bioaccumulation potential at different trophic levels, absence or low capacity of biotransformation at lower trophic levels, significance of dietary uptake at higher trophic levels, inherent toxicity for sensitive predators.

In the past decade various protocols have been developed for the evaluation of the risks of potential secondary poisoning in terrestrial and aquatic food chains, and the incorporation of this in the development of environmental quality criteria (Jonkers and Everts 1992, Luttik *et al.* 1992 and 1993, Van de Plassche *et al.* 1993 and 1994, Romijn *et al.* 1991 1993 and 1994, US-EPA 1995). In the Dutch protocols usually a survey is made of available and reliable avian and mammalian chronic diet-based NOEC data (mortality, growth, reproduction), followed by extrapolation to a generic diet-based NOEC, accounting for the uncertainty in the basic data. Using evaluated BCF data the diet-based NOECs are translated to MPCs (maximum permissible concentrations) for water, sediment, suspended matter or terrestrial soils. If the secondary poisoning-based MPC is lower than the ecosystem based-MPC (derived from direct effects on plants, invertebrates and fish), than this value is taken for further derivation of environmental quality objectives. Such an assessment has to date been made for various compounds: lindane, dieldrin, cadmium, mercury, DDT, PCP (Van de Plassche *et al.* 1994). An overview of diet-based NOECs, derived in Van de Plassche *et al.* (1994), is presented in Annex A.11. Recently this approach was applied to trace metals and 70 individual pesticides (Crommentuyn *et al.* 1997).

In Table 7 some key properties and parameters (K_{ow}, BCF, BMF) are listed, describing the potential for biomagnification and food chain transfer of the various categories of compounds included in this study.

Table 7. Hydrophobicity, bioconcentration and biomagnification data reported for selected contaminants in zebra mussels and eel.

Compound	Log K_{ow} approx. range [a]	BCFfish L/kg wet weight [b]	BMF (lipid w) [b] case	value
PBBs	5 - 8	63.10^3 - $1.2.10^6$	grey seal - herring	140
PBDEs	6 - 7			
Chlorophenols	2 - 4.2	1 - 12180	duck - comm. feed	0.04
Chloronitrobenzenes	2 - 3.5	77 - 176		
TCPM	6 - 6.5[c]		fish - mar. mammal	10-100
Toxaphene	6.4 [d]	3625 - 76000	fish - crustaceans	14
Chlordanes	5 - 6 [e]	9000 - 37800	herring gull - fish	60
Chloroterphenyls	> 5 [f]			
Chlorobenzyltoluenes	6.7 - 7.4 [g]	47 - 479		
Phthalates	1.5 - 7.5	13 - 886		

[a] K_{ow} data as included in Hendriks *et al.* (1998, chapter 2), [b] range of wet weight based BCFs listed in Annex A.7 and lipid-normalised BMFs from Annex A.8, [c]CLogP value cited by De Boer *et al.* (1996), [d]according to Saleh (1991), [e]data from Simpson *et al.* (1995), [f]no literature values encountered, range proposed on CLogP predictions, [g] based on Van Haelst (1996)

Persistent compounds with $LogK_{ow} > 6$ may exhibit significant dietary uptake, and food chain transfer or biomagnification (Gobas 1989, Thomann 1989, Suedel *et al.* 1994), Hendriks 1995). Most of the chlorophenols, chloronitrobenzenes and phthalates are not likely to be transferred along food chains. This is confirmed by the pattern of BCF data and the BMF reported for chlorophenols.

Available mammalian, avian toxicity data, together with data from other relevant experiments (with dietary exposure), listed in Annex A.4 and A.5, have been summarised for the different classes of compounds in Table 8.

As expected, much information was available on toxaphene and chlordane, which have previously been subject to review by international committees of WHO, UNEP, FAO and ILO (e.g. IPCS 1984a,1984b 1984c). For chlorophenols a national criteria document, with reviewed and evaluated toxicity data was available (Slooff *et al.* 1991, Janus *et al.* 1991). For the other compounds much less information is available, in many cases limited to acute or short term mammalian studies with single oral dosages. Chronic NOEC data for mortality, reproduction or growth were identified for some chlorophenols, toxaphene, chlordane, heptachlor, and several phthalates. Insufficient chronic data were noted for bromobiphenyls, bromodiphenylethers, chloronitrobenzenes, tris(4-chlorophenyl)methanol/ane, polychlorinated terphenyls and tetrachlorobenzyltoluenes. As some of the basic data could not be retrieved and checked within the 3 month duration of the project, no extrapolations were applied, such as e.g. the conversion of acute single-dosage LD_{50} data to acute diet-based LC50 values, or the estimation of generic avian or mammalian diet-based chronic NOECs.

Table 8. Summary of avian, mammalian and other toxicity data.

Compound	Avian Toxicity endpoint	value $mg \cdot kg^{-1}$diet	Mammalian Toxicity endpoint	value $mg \cdot kg^{-1}$diet	Fish, amphibian endpoint	value $mg \cdot kg^{-1}$diet
PBBs			LC_{50} / C50 ac.	4-100	fish LC50 (42d)	8
			NOEC (carc) chr.	3	fish LD50 ac.	0.4-230 bw/d
PBDEs			EC_{50} (30d)	1-10		
			Generic $NOEC_{extr}$	0.1		
Chlorophenols	NOEC, repr	100-600	NOAEL	14-1400 bw/d	frog NOEC, 27d	638
	Generic $NOEC_{extr}$	24.5	NOEC chr.	50-200		
			Generic $NOEC_{extr}$	5.5		
Chloronitrobenzenes			LD_{50} ac.	135-2850		
Toxaphene	EC_{50} subchr.	5-10	NOAEL chr.	0.3-0.4 bw/d		
Chlordanes	LC_{50} (ac.-subchr.)	10-860	LD50 ac.	20-1720		
			NOEC chr.	3-150		
Heptachlor	LC_{50} ac.	80-480	LD_{50} ac.	27-250 bw		
	NOEC 10-16w	50	NOEC chr.	5-7		
Heptachlor-epoxid	NOEC 25w	0.02-0.2	NOEC chr.	7-20		
Chloroter-phenyls	NOEC, 9w	20	EC50, 24 w	250-550		
Phthalates	EC_{50} ac.	2000-5000	NOEL, chr.	50-100 bw/day	frog LOAEC, chr.	15-25
	NOEC chr.	10				

abbreviation: ac.=acute, subchr.=subchronic, chr.=chronic, repr.= reproduction, carc.=carcinogenesis, extr.=extrapolated generic value. Endpoints are expressed as concentrations in the diet in $mg \cdot kg^{-1}$wet weight, unless otherwise indicated (e.g. bw/day: $mg \cdot kg^{-1}$bodyweight per day, bw: in $mg \cdot kg^{-1}$bodyweight for single oral dosages in acute toxicity experiments). Basic data and references are listed in Annex sections A4, A5 and A6.

3.4 Ecotoxicological risks

In Table 9 various critical levels for direct effects in fish (CBR, Nendza *et al.* 1997) and secondary poisoning, i.e. diet-based avian and mammalian NOECs extrapolated from laboratory studies and the (laboratory) diet-based NOECs from specific assessments (mink, bald eagle) are presented. Also listed are the equivalent concentrations in fish and bivalves corrected for differences in caloric content between standard laboratory feed and biota from natural habitats (Beek 1995, Den Besten 1993).

These corrected values have been used in Dutch location-specific risk assessment studies in areas with contaminated sediments. Added to these series are the 2,3,7,8-TCDD based critical concentrations of toxic PCB congeners.

The laboratory feed-based generic NOECs are not exceeded. The related critical levels derived for secondary poisoning in fish-consumers are exceeded for DDT, heptachlorepoxide, and non- en mono-ortho substituted PCBs. For shellfish eating predators only the critical levels for non- en mono-ortho substituted PCB are exceeded.

The diet-based NOECs for mink, otter and bald eagle are exceeded for total PCBs and toxic coplanar congeners.

The concentrations of bromobiphenyls are well below the chronic NOEC for carcinogenic effects. The bromodiphenylether concentrations in eel are at 6 to 50% of the extrapolated generic NOEC of 100 $\mu g \cdot kg^{-1}$ wet weight, mentioned in Pijnenburg *et al.* (1995). Incorporating corrections for lab-field differences in caloric content of prey- or food-items, would result in an approximation or transgression of this NOEC.

For both bromobiphenyls and bromodiphenylethers TCDD-like action has been demonstrated (Hornung *et al.* 1996). The 2,3,7,8-TCDD toxicity equivalent factors of bromobiphenyls are in the range of PCBs with similar substitution patterns. Similarly, Ah-receptor binding affinity and induction of EROD has been reported for tetrachlorobenzyltoluene congeners (Murk *et al.* 1991). As the concentrations of tetrachlorobenzyltoluenes and the brominated compounds are relatively low compared to PCBs, it is expected that the contribution to total dioxin equivalents probably will be negligible.

The diet-based NOEC and other effect levels for chloronitrobenzenes, chlordane, toxaphene, phthalates suggest that additional risks (mortality, growth, reproduction) for these compounds probably will be negligible.

No information is available on the potential induction of estrogenic activity, which has been related in vitro experiments to some phthalates (IPCS 1996), and various other compounds included in this study, such as PCB metabolites, p,p'-DDE and toxaphene.

In summary, the present results indicate that current levels in eel and zebra mussels may imply risks for secondary poisoning in sensitive predators for non- and mono-ortho substituted PCBs, DDE or heptachlorepoxide and possibly bromodiphenylethers. Based on the available information the risks for secondary poisoning due to other compounds, such as chloronitrobenzenes, toxaphene, phthalates, chlordane and tetrachlorobenzyltoluenes seem to be limited. The concentrations of HCB and planar PCBs in eel exceed at some locations prevailing human consumption standards.Human consumption quality standards

Table 9. Summary of estimated critical body residues (NOEC, CBR in µg·kg^{-1} wet weight) for fish and diet-based critical levels (NOEC in µg·kg^{-1} wet weight) for secondary poisoning in birds and mammals.

Compound	CBR direct effects fish; NOEC from lab. studies [a]	Secondary poisoning birds, mammals Experimental NOECs extrapolated from laboratory studies [b]			Critical levels (NOEC) derived from specific assessments for mink, otter, bald eagle [d]	Based on other diet-based endpoint in Table 8 Chronic NOEC unless indicated otherwise
		diet in experiments	extrapolated to **fish** [c]	extrapolated to **bivalves** [c]		
PBBs						3000
PBDEs						100
Chlorophenols	**40**	5500-24500	5000-11000	4750		
Chloronitro-benzenes						135000-2850000 (LD50 ac.)
Toxaphene						300-400
Chlordanes		3000-3300				
Heptachlor		600-900	190-410	170		
Heptachlorep-oxide		2-700	**0.5-1**	0.5		
Chloroterphenyls						20,000 (NOEC 9w)
Phthalates						10,000
QCB		500				
HCB	2250	70-500	180-230	95		
p,p'-DDT/DDE	**90**	210-7350	**40-70**	20-40	160	
Endosulfan		680-8100				
Dieldrin		290-350	100-130	55	14	
y-HCH	**15**	160-2500				
Hg	58		140-180	76		
Methyl-Hg		90-100	33-42	18	50	
PCBs (total)	**29**				11-140	
2378-TCDD			**0.001-0.002**	**0.0008**	**0.0004-0.017**	

[a] Basic data from Nendza *et al.* (1997), presented in Annex A.11.1, [b] Basic data from Romijn *et al.* (1993), Van de Plassche *et al.* (1994) summarised in Annex A.11.2, [c] Extrapolation based on caloric content of laboratory feed versus prey-items in field situation, source: Jongbloed *et al.* (1994), Beek (1995), Den Besten *et al.* (1993), [d] Data from Giesy *et al.* (1994 1995), Tillit *et al.* (1996), Leonards *et al.* (1994) and Leonards (1997) presented in Annex A.11.3. Concentrations in zebra mussels and eel (Chapter 2) exceeding endpoint-values are indicated in bold.

3.5 Human consumption quality standards

Critical levels for human consumption for several OECD countries are included in Table 10. Some of the Dutch standards are provisional values. Only the HCB concentrations in eel exceed the proposed standard of 50 $\mu g \cdot kg^{-1}$ wet weight. Non-ortho and mono-ortho substituted PCB concentrations in eel from the Rhine (0.026 $\mu g \cdot kg^{-1}$ wet weight) and Hollands Diep (0.116 $\mu g \cdot kg^{-1}$ wet weight) are exceeding the 2,3,7,8-TCDD based Canadian standard of 0.02 $\mu g \cdot kg^{-1}$ wet weight.

Table 10. Summary of ADI (acceptable daily intake) and human consumption standards (Maximum Tolerable Concentration, MTC) for chlorinated compounds in fish and shellfish products.

Compound	WHO- ADI $mg \cdot kg^{-1} bw \cdot d^{-1}$	MTC Netherlands $\mu g \cdot kg^{-1}$wet weight	MTC Germany $\mu g \cdot kg^{-1}$ fat weight	MTC USA $\mu g \cdot kg^{-1}$wet weight	MTC Canada $\mu g \cdot kg^{-1}$wet weight
Chlorophenols					
2,4-dichlorophenol	0.003				
2,4,5-trichlorophenol	0.1				
2,3,4,6,-tetrachlorophenol	0.01				
Pentachlorophenol	0.03				
Hexachlorobenzene		**50**	50-500		
HCHs		50	500		
Dieldrin, Aldrin		50	1000		
DDTs (incl DDE, DDD)		500	3500		5000
Toxaphene	0.2		100*		
Chlordanes	0.0005	20-100	50	300	
Heptachlor	0.0001	20-100	10	300	
PCB-153		**100-500**	300		
PCBs (total)		1000-5000		5000	2000
2,3,7,8-TCDD	$1 . 10^{-9}$				**0.02**

Sources: Details in Annex A3, Janus *et al.* (1991), IPCS (1989), Janus *et al.* (1991), Janssen & van Leeuwen (1993), FAO(1996), 71, RHMV (1994), Van der Valk (1989), CCRX(1990), JECFA (1995). Values (regularly) exceeding MTCs have been indicated in bold. *wet weight basis, sum of tpxphene congeners 25, 50 and 62.

4. Conclusions

A literature survey was carried out on critical concentrations for non-priority substances with an accumulation potential. The following conclusions can be drawn.

1. Concentration levels of non-priority substances in the Rhine-Meuse basin are comparable to levels observed in other industrialised countries, but well below concentrations reported for some local incidentally heavily polluted areas.
2. Biomagnification and food chain transfer is not believed to be of significance for most of the chlorophenols, chloronitrobenzenes and phthalates.
3. A limited number of chronic NOECs for mortality, reproduction or growth could be identified for some chlorophenols, toxaphene, chlordane, heptachlor, and several phthalates.
4. Insufficient chronic toxicity data exist for bromobiphenyls, bromodiphenylethers, chloronitrobenzenes, tris(4-chlorophenyl)methanol/ane, polychlorinated terphenyls and tetrachlorobenzyltoluenes.
5. PBDE concentrations in eel are at 6 to 50% of a reported generic NOEC. Taking in to account corrections for lab-field differences in caloric content of prey- or food-items, this could probably mean that this NOEC may be exceeded in sensitive predators.
6. Based on limited toxicity data available for TCPm and TCPMe and the occurrence of these compounds in concentrations approaching individual DDE isomers or PCB congeners, further studies are recommended.
7. Diet-based NOEC and other effect levels for chloronitrobenzenes, chlordane, toxaphene, phthalates suggest that additional risks of secondary poisoning due to exposure to these compounds probably will be negligible.

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Annex

A.1 Retrieval of data from electronical databases

Data were obtained from literature and technical reports, identified with on-line searches in electronical databases (Chemical Abstracts, Biological Abstracts, Current Contents, Toxline, Aquatic & Fisheries Sciences, NTIS) available at different host organisations (Dialog and STN). For all compounds the CAS-nrs. were used is the primary identifiers. Official IUPAC names, common names, trade names, synonyms and molecular formulas of the compounds were used as secondary identifiers. Various compound-categories were technical mixtures of many different congeners or homologs (i.e. PBBs, PBDEs, Toxaphene, Chlordanes, TCBTs, PCTs) usually with a poorly defined composition. For some mixtures no CAS-nrs were available, or sometimes more than one CAS-nr was encountered. For individual components of mixures, CAS nrs were as far as possible retrieved from the STN database (see e.g. section A.2) .

The compound identifiers were combined with a search profile describing the subjects and issues relevant for the present study. In most cases the search profile consisted of a combination of the following (truncated) keywords: *bioconcentration, uptake, accumulation, bioaccumulation, toxicokinetics, biotransformation, biomagnification, food chain or trophic transfer, BCF, BMF, occurence, level, tissue residue, monitoring,avian and mammalian toxicity, no-effect, ADI, MTC, NOEC, NOAEL, LD50, LC50, ED50, EC50*. For compounds with numerous hits, the seletion was narrowed down by focusing mainly on review articles or monographs. For compounds for which no hits were recorded, the search profile was broadened. Although it is realized that this procedure may not fully cover all material published, this approach usually yielded information for most compounds within the limited time frame of the project.

Usufull citations were incuded in a literature management database (Reference Manager), which contained apporximately 700 creferences. During the retrieval of selected publications priority was given to reviewed sources or data sets, as a thorough evaluation of the quality of data in primary sources was beyond the scope of this study. Therefore, use was made in many cases of secondary sources, such as reviews, criteria-documents (e.g. IPCS-publications), databases of qualified ecotoxicological data (e.g. AQUIRE, DOSE, EINECS). Many primary source publications were present in the extensive archives of the RIVO-DLO (IJmuiden, Netherlands) and could be made available within the time-frame of the project. The appropriate basic data were collected in an Excel spreadsheet database, and are listed in Annex A.3 to A.10).

A.2 Compounds, CAS-nrs

Category, group	Individual substances, mixtures	CAS-nr	Formula, symbol
Brominated biphenyls	brominated biphenyls (m)		C12H(10-x)Brx
	2,2',4,5'-tetra-bromobiphenyl	60044-24-8	C12H6Br4
	2,2',5,5'-tetra-bromobiphenyl	59080-37-4	C12H6Br4
	2,2',4',5,5'-penta-bromobiphenyl	67888-96-4	C12H5Br5
	2,2',4,4',5,5'-hexa-bromobiphenyl	59080-40-9	C12H4Br6
	2,2',4,4',6,6'-hexa-bromobiphenyl	59261-08-4	C12H4Br6
	3,3',4,4',5,5'-hexa-bromobiphenyl	60044-26-0	C12H4Br6
	mono-bromobiphenyls	26264-10-8	C12H9Br
	di-bromobiphenyls	27479-65-8	C12H8Br2
	tri-bromobiphenyls	51202-79-0	C12H7Br3
	tetra-bromobiphenyls	4008-45-7	C12H6Br4
	penta-bromobiphenyls	56307-79-0	C12H5Br5
	hexa-bromobiphenyls	36355-01-8	C12H4Br6
	hepta-bromobiphenyls	35194-78-6	C12H3Br7
	okta-bromobiphenyls	27858-07-7	C12H2Br8
	nona-bromobiphenyls	27753-52-2	C12HBr9
	decabromobiphenyl	13654-09-6	C12Br10
Brominated diphenylethers	brominated diphenylethers (m)		C12HxBryO
	tetra-bromobiphenylethers (m)	40088-47-9	C12H6Br4O
	penta-bromobiphenylethers (m)	32534-81-9	C12H5Br5O
Chlorinated phenols	4-monochlorophenol	106-48-9	C6H5ClO
	2,4-dichlorophenol	120-83-2	C6H4Cl2O
	2,6-dichlorophenol	87-65-0	C6H4Cl2O
	2,4,5-trichlorophenol	95-95-4	C6H3Cl3O
	2,4,6-trichlorophenol	88-06-2	C6H3Cl3O
	2,3,4,6,-tetrachlorophenol		C6H2Cl4O
	pentachlorophenol	87-86-5	C6HCl5O
Chloro nitrobenzenes	1-chloro-2-nitrobenzene	88-73-3	C6H4ClNO2
	1-chloro-3-nitrobenzene	121-73-3	C6H4ClNO2
	1-chloro-4-nitrobenzene	100-00-5	C6H4ClNO2
	1,2-dichloro-3-nitrobenzene	3209-22-1	C6H3Cl2NO2
	1,2-dichloro-4-nitrobenzene	99-54-7	C6H3Cl2NO2
	1,3-dichloro-4-nitrobenzene		C6H3Cl2NO2
	2,4-dichloro-1-nitrobenzene	611-06-3	C6H3Cl2NO2
	1,4-dichloro-2-nitrobenzene	89-61-2	C6H3Cl2NO2
Tris(4-chlorophenyl)-compounds	Tris(4-chlorophenyl)methane	27575-78-6	C19H13Cl3
	Tris(4-chlorophenyl)methanol	3010-80-8	C19H12Cl3OH
Toxaphene	Toxaphene (m)	8001-35-2	C10H10Cl8

Category, group	Individual substances, mix-	CAS-nr	Formula, symbol
Chlordanes	Chlordanes (m)	57-74-9	C10H6Cl8
	cis-chlordane	5103-71-9	C10H6C18
	trans-chlordane	5103-74-2	C10H6C18
	alpha-chlordane		C10H6C18
	gamma-chlordane		C10H6C18
Oxychloordane	Oxychlordane	27304-13-8	C10H..Cl..
Chlordenes	Chlordenes (m)	3734-48-3	C10H6Cl6
	Chlordenes (m)		C10H5Cl7
	cis-chlordene	3734-48-3	C10H6C16
	trans-chlordene		C10H6C16
Heptachlors	heptachlor (mixture)		C10H5Cl7
	heptachlor	76-44-8	C10H5Cl7
	heptachlorepoxide	1024-57-3	C10H5Cl7O
	nonachlor (m)	39765-80-5, 3734-	C10H5Cl9
Nonachlors	trans-nonachlor	3734-49-4, 39765-	C10H5Cl9
	cis-nonachlor	29555-47-3, 5103-	C10H5Cl9
Chloro-anisols	penta-chloroanisol	1825-21-4	C6Cl5-O-CH3
	penta-chlorothioanisol	1825-19-0	C6Cl5-S-CH3
Polychlorinated terphen-	Chloroterphenyls	61788-33-8	C18H14-nCln
Polychlorinated benzyl-toluenes	polychlorinated benzyl-toluenes (m)		C14HxClyx=10-y
	tetrachlorobenzyltoluenes (m)	76253-60-6	C14H11Cl4
Phthalates	dimethylphthalate	131-11-3	C10H10O4
	diethylphthalate	84-66-2	C12H14O4
	dioctylphthalate	27554-26-3	C24H38O4
	di-2-ethyl-hexylphthalate	117-81-7	C16H22O4

A.3 Human consumption standards

Individual substances	CAS nr.	ADI/TDI	Country	MTR	Warenwet NL	Unit	Remark	References
brominated biphenyls (m)		<0.00015				mg/kg kw/day	tentative value proposed in summary report using NOAEL carc. study and factor 1000	IPCS (1994)
2,4-dichlorophenol	120-83-2	0.003				mg/kg bw/day	RIVM, extrapolated; IPCS (1989): 0.2 mg/kg bw/day	Janus *et al.* (1991)
2,4,5-trichlorophenol	95-95-4	0.1				mg/kg bw/day		IPCS (1989)
2,3,4,6,-tetrachlorophenol		0.01				mg/kg bw/day		IPCS (1989)
pentachlorophenol	87-86-5	0.03				mg/kg bw/day	RIVM, extrapolated	Janus *et al.* (1991)
toxaphene (m)	8001-35-2	0.2				ug/kg bw/day	Canada TDI. WHO/FAO No TDI due to lifelong biacc	Muir and De Boer (1995)
			Germany	0.1-0.4		mg/kg lw	meat, fishproducts	RHMV (1994)
chlordanes (m)	57-74-9	0.0005				mg/kg bw/day	WHO/FAO PTDI	JECFA (1995)
					0.05	mg/kg ww	eel, fish liver 0.1 , other products 0.02, including oxychlordane	CCRX(1990)
			Germany	0.05		mg/kg lw	incl. oxychlordane; meat,milk, eggs (other products 0.01)	RHMV (1994)
			USA	0.3		mg/kg ww	incl oxychlordane	Van der Valk (1989)
heptachlor (mixture)		0.0001				mg/kg bw	WHO/FAO PTDI	JECFA (1995)
					0.05	mg/kg ww	eel, fish liver 0.1 , other products 0.02, including heptachlorepoxide	CCRX(1990)
			Germany	0.01		mg/kg lw	incl. hepo; other products; meat, eggs: 0.2; milk: 0.1	RHMV (1994)
			USA	0.3		mg/kg ww	incl heptachlorepoxide	Van der Valk (1989)

A.4 Avian toxicity data

Individual substances, mixtures	CAS-nr	Species	Parameter	Conc.	Unit	Remarks	References
pentachlorophenol	87-86-5	Anas platyrhynchos	NOAEL,gr,11 d	423	mg/kg diet (w.wt?)		Nebeker *et al.*, (1994)
		Gallus domesticus	NOEC, r, 8 w	100	mg/kg diet		Stedman *et al.* (1980) in Romijn *et al.* (1994)
		Gallus domesticus	NOEC, r, 8 w	600	mg/kg		Prescott et al (1982) in Romijn *et al.* (1994)
		Gallus domesticus	NOEC, r	245	mg/kg	median value from reviewed studies	Romijn *et al.* (1994)
toxaphene (m)	8001-35-2	Anas rubripes, American black duck	EC, g, development, 90 d	10	mg/kg diet	Contradictory results in Haseltine *et al.* (1980) in Saleh (1991)	Mehrle *et al.* (1979) in Saleh (1991)
		Northern bobwhite	EC, mrophol., 4 month	5	mg/kg diet	thyroid hypertrophy	Pollock and Kilgore (1978) in Saleh (1991)
chlordanes (m)	57-74-9	Anas platyrhynchos	LC50, 5d	860	mg/kg diet		Hill and Heath (1975) in Van de Plassche *et al.* (1994)
		Coturnix c. japonica	NOEC,m.,127d	< 0.5	mg/kg diet	16-20 w juvenils	DeWitt (1956) in Van de Plassche *et al.* (1994)
		Phasianus colchinus	NOEC, r, ?d.	1	mg/kg diet	adults	DeWitt (1956) in Van de Plassche *et al.* (1994)
		birds (5 species)	LC50, 5-100d	10 - 858	mg/kg diet	range of values from studies reviewed	IPCS (1984)
heptachlor (mixture)		Colinus virginianus	LC50, 5d	93	mg/kg diet		Hill and Heath (1975) in Van de Plassche *et al.* (1994)
		Coturnix c. japonica	NOEC,r,16w	50	mg/kg diet	chicks 0d	IPCS-38 (1984a) in Van de Plassche *et al.* (1994)
		Phasianus colchinus	LC50, 5 d	220	mg/kg diet	juv. 8d.	Hill and Heath (1975) in Van de Plassche *et al.* (1994)

A.4. Avian toxicity data (continued*)*

Individual substances, mixtures	CAS-nr	Species	Parameter	Conc.	Unit	Remarks	References
heptachlorepoxide	1024-57-3	Gallus domesticus	NOECm,g-r,25w	0.02 - 0.2	mg/kg diet	chicks	Wolvin *et al.* (1969), IPCS (1984), Van de Plassche *et al.* (1994)
chloroterphenyls	61788-33-8	White leghorn chickens	NOEC, r, 9w	20	mg/kg ww diet	hatchability, dose produced no effects	Lillie *et al.* (1974), Cecli *et al.* (1974) in Jensen and Jo/rgensen (1983)
di-2-ethyl-hexylphtalate	117-81-7	Broiler hens	EC, r, g, 28 d	2000	mg/kg diet ww	significant reduction	Wood and Bitman (1984); IPCS (1992)
		hen	EC, r, morf., 230 d	5	g/kg diet ww		Ishida *et al.* (1982); IPCS (1992)
		Streptopelia risoria, ring dove	NOEC, r, g, m, ? d	10	mg/kg diet		Peakall (1974); IPCS (1992)

A.5 Mammalian toxicity data

Individual substances, mixtures	CAS-nr	Mammals	Parameter	Concentration	Unit	Remarks	References
brominated biphenyls (m)		Mustela vison	LC50	3.95	mg/kg ww diet	Firemaster FF-1, acute tox	Safe (1984) in Pijnenburg *et al.* (1995)
		Rat	LD50	65-149	mg/kg/d	acute tox, females 65, males 149, Firemaster BP-6	Gupta *et al.* (1983a) in Pijnenburg *et al.* (1995)
		Rat (f)	EC100, m, 22 d	100	mg/kg diet	mortality after 90 days	Gupta *et al.* (1983b) in Pijnenburg *et al.* (1995)
		rat	NOAEL, LOAEL, carcinogenesis, 2 yr	0.15 / 0.5	mg/kg bw/day	hepatic carcinoma's; NOEC-LOEC: 3 / 10 mg/kg diet	NTP (1993) in IPCS (1994)
nona-bromobiphenyls	27753-52-2	rat, mice	NOAEL, carc, 1 gen.	0.15	mg/kg bw /day	carcinogenesis, LOAEL 0.5 mg/kg bw /day	Momma (1986) in Boon *et al.* (1997)
brominated diphenylethers (m)		rat	EC, 30 d	1-10	mg/kg ww diet	incr. liver weight, thyroid hyperplasia	Norris *et al.*(1975) in Pijnenburg *et al.* (1995)
		var. species	NOEC	0.1	mg/kg ww diet	generic NOEC, eq. to 8 mg/kg bw/day	Pijnenburg *et al.* (1995)
2,4-dichlorophenol	120-83-2	rat	NO(A)EL subacute	640-1400	mg/kg bw/dag		Slooff *et al.* (1991)
2,4,5-trichlorophenol	95-95-4	rat	NO(A)EL subacute	225	mg/kg bw/dag		Slooff *et al.* (1991)
2,4,6-trichlorophenol	88-06-2	rat	NO(A)EL subacute	1000-1400	mg/kg bw/dag		Slooff *et al.* (1991)
pentachlorophenol	87-86-5	rat	NO(A)EL subacute	14-50	mg/kg bw/dag		Slooff *et al.* (1991)
1-chloro-2-nitrobenzene	88-73-3	rat, rabbit, mouse	LD50, acute, oral	135-288	mg/kg bw	no further info	Richardson and Gangolli (1997)
1-chloro-3-nitrobenzene	121-73-3	mouse, rat	LD50, acute, oral	390-470	mg/kg bw	no further info	Richardson and Gangolli (1997)

A.5 Mammalian Toxicity Data (continued)

Individual substances, mixtures	CAS-nr	Mammals	Parameter	Concentration	Unit	Remarks	References
1-chloro-4-nitrobenzene	100-00-5	mouse, rat	LD50, acute, oral	420-650	mg/kg bw	no further info	Richardson and Gangolli (1997)
1,2-dichloro-3-nitrobenzene	3209-22-1	rat	LD50, acute, oral	643	mg/kg bw	no further info	Richardson and Gangolli (1997)
1,4-dichloro-2-nitrobenzene	89-61-2	mouse, rat	LD50, acute, oral	1210-2850	mg/kg bw	no further info	Richardson and Gangolli (1997)
tris(4-chlorophenyl) methanol	3010-80-8	rat	NOEC, morf, 28 d	1	mg/kg diet	hepatic effects, splenomegaly, white blood cells at 10 and 100 mg/kg (1.2 and 12 mg/kg bw/day	Poon *et al.* (1997)
toxaphene (m)	8001-35-2	rat	NOAEL, 13 w	0.35	mg/kg bw/day	liver and kidney damage, NOEC 4 mg/kg diet	Chu *et al.* (1986)
		dog	NOAEL, 13 w	0.2	mg/kg bw/day	liver, kidney damage	Chu *et al.* (1986)
		Rat, rabbit	LD50 acute	49 - 500	mg/kg bw / day	range of values for oral exposure reviewed in	IPCS (1984), Saleh (1991)
chlordanes (m)	57-74-9	Rattus norvegicus	NOEC, r, 3-gen	30	mg/kg diet		FAO/WHO (1967) in Van de Plassche *et al.* (1994)
		Oryctolagus cuniculus	LOEC m, 16-24d	10	mg/kg bw		ATSDR (1989) in Van de Plassche *et al.* (1994)
		Mus musculus	NOEC, m, 6 w	10.4	mg/kg bw		ATSDR (1989) in Van de Plassche *et al.* (1994)
		rat, rabbit, hamster	LD50, acute	20 - 1720	mg/kg bw	range of 7 studies reviewed	IPCS (1984)

A.5 Mammalian Toxicity Data (continued)

Individual substances, mixtures	CAS-nr	Mammals	Parameter	Concentration	Unit	Remarks	References
heptachlor	76-44-8	Rattus norvegicus	NOEC, r,m,g, chronic	5-7	mg/kg diet		FAO/WHO (1970) in Van de Plassche *et al.* (1994)
		rat, mouse, rabbit, hamster, guinea pig	LD50 acute	27 - 250	mg/kg bw		IPCS (1994)
heptachlorepoxide	1024-57-3	Rattus norvegicus	NOEC, r,m,g, chronic	7-20	mg/kg diet		Van de Plassche *et al.* (1994), IPCS (1984)
		Canus domesticus	NOEC,r,m,g, chronic	0.5 and 7	mg/kg bw/day and mg/kg diet		Van de Plassche *et al.* (1994), IPCS (1984
chloroterphenyls	61788-33-8	mice	EC,g, 24 w	250-550	mg/kg ww diet	body weight, subchr. study	Shirai *et al.* (1978) in Jensen and Jo/rgensen (1983)
di-2-ethylhexylphtalate	117-81-7	rat	NEL, chronic	0.1	g/kg bw/day	liver damage	Carpenter *et al.* (1963) in Wams (1987)
		rat	NOAEL, m,	50	mg/kg bw/day	hepatic hyperplasia	IPCS (1992)

A.6 Fish, invertebrate, amphibian toxicity data

Individual substances, mixtures	CAS-nr	Species	Parameter	Concentration	Unit	Remarks	References
brominated biphenyls (m)		Salmo salar, atlantic salmon	LC100, 42 days	7.75	mg/kg diet ww	mixture of di,tri and tetrabromobiphenyls	Zitko and Hutzinger (1976) in IPCS (1994)
2,2',5,5'-tetra-bromobiphenyl	59080-37-4	Salmo gairdneri	LD50, 24-48 h, ELS	> 172000	ng/g egg ww	PBB-52	Hornung *et al.* (1996)
2,2',4,4',5,5'-hexa-bromobiphenyl	59080-40-9	Salmo gairdneri	LD50, 24-48 h, ELS	> 230000	ng/g egg ww	PBB-153	Hornung *et al.* (1996)
3,3',4,4',5,5'-hexa-bromobiphenyl	60044-26-0	Salmo gairdneri	LD50, 24-48 h, ELS	3910 (1510-6460)	ng/g egg ww	PBB-169, TEF = 0.00012	Hornung *et al.* (1996)
di-bromobiphenyls	27479-65-8	Salmo gairdneri	LD50, 24-48 h, ELS	> 114000	ng/g egg ww	PBB-4, 2,2'-DBB	Hornung *et al.* (1996)
tetra-bromobiphenyls	4008-45-7	Salmo gairdneri	LD50, 24-48 h, ELS	434 (353-503) to > 172000	ng/g egg ww	PBB-77, TEF=0.0016 and PBB-52	Hornung *et al.* (1996)
hexa-bromobiphenyls	36355-01-8	Salmo gairdneri	LD50, 24-48 h, ELS	3910 - > 230000	ng/g egg ww	PBB-169 and PBB-153	Hornung *et al.* (1996)
tetra-bromobiphenyl-ethers (m)	40088-47-9	Salmo gairdneri	LD50, 24-48 h, ELS	> 12000	ng/g egg ww	2,2',4,4'-TBDE	Hornung *et al.* (1996)
penta-bromobiphenylethers (m)	32534-81-9	Salmo gairdneri	LD50, 24-48 h, ELS	> 12000	ng/g egg ww	2,2',3,4,4'-PBDE and 2,2',4,4',5-PBDE	Hornung *et al.* (1996)
pentachlorophenol	87-86-5	Xenopus laevis	NOAEL, feeding activity, 27d	638	mg/kg diet ww		Schuytema *et al.* (1993)
di-2-ethyl-hexylphtalate	117-81-7	Pimephales promelas	NOEC, gr, m, 56 d	62	ug/L	adult	Mehrle and Mayer, 1976
		Salmo gairdneri	NOEC, m, 12 d	5-14	ug/L	eggs, at 10 oC, later stages less susc.	Mehrle and Mayer, 1976
		Rana arvalis, moor frog	LOAEC, r, 60d	5-10 ug/L, 15-25 mg/kg sed.	ug/L, sed mg/kg ww	data read from fig.	Larsson and Thuren (1987)

A.7 Bioconcentration data

Individual substances	CAS-nr	Species	BCF	Unit	Duration	Exposure conc.	Remarks	References
2,2',4,5'-tetra-bromobiphenyl	60044-24-8	Salmo salar	314000000	whole boy ww				Zitko and Hutzinger (1976) in Pijnenburg *et al.* (1995)
2,2',5,5'-tetra-bromobiphenyl	59080-37-4	Poecilia reticulata	1445440	ww/lw?				Gobas (1989) in Pijnenburg *et al.* (1995)
2,2',4,4',6,6'-hexa-bromobiphenyl	59261-08-4	Poecilia reticulata	707946	ww/lw?				Gobas (1989) in Pijnenburg *et al.* (1995)
2,4-dichlorophenol	120-83-2	Carassius auratus	34	whole body ww	7 d	RSD		Hall and Jacob (1988) in Aquire (nr. 833)
		Trachurus novaezelandiae, fish	39.7	ww	40 h	100 ug/L		Jennings *et al.* (1996)
		Mytilus edulis	59.5	ww	40 h	100 ug/L		Jennings *et al.* (1996)
2,4,5-trichlorophenol	95-95-4	Pimephales promelas	1800-1900		1-28 d	RSD		Call *et al.* (1980) in Aquire (6402)
2,4,6-trichlorophenol	88-06-2	Poecilia reticulata	1020-12180		21-36 d	RSD		Virtanen and Hattula (1982) in Aquire (10624)
		Jardanella floridae	88		28 d	RSD		Smith *et al.* (1990) in Aquire (3116)
		Anadonta anatina	1130-1140	lipid wt.	10 d	20 ug/L,	lipid 4.9%	Englund and Heino (1996)
		Trachurus novaezelandiae, fish	95.9	ww	40 h	100 ug/L		Jennings *et al.* (1996)
		Mytilus edulis	29	ww	40 h	100 ug/L		Jennings *et al.* (1996)
pentachlorophenol	87-86-5	Fish species (freshw.)	1-1000	whole body, ww	< 5 days	50-200ug/L	various freshw. spec.	Slooff *et al.* (1991)
		Salmo gairdneri	260-750	whole body ww	16 weeks	0.035-0.66 ug/L		Slooff *et al.* (1991)

A.7 Bioconcentration Data (Continued)

Individual substances	CAS-nr	Species	BCF	Unit	Duration	Exposure conc.	Remarks	References
pentachlorophenol	87-86-5	Pimephales promelas	281-1066		32d	RSD		Spehar *et al.* (1985) in Aquire (10679)
		Fish, various species	135	ww		INS - review of various studies, geom. mean value = 135, range 17 - 770		Van de Plassche *et al.* (1994)
		Trachurus novaezelandiae, fish	283	ww	40 h	100 ug/L		Jennings *et al.* (1996)
		Mytilus edulis	95.3	ww	40 h	100 ug/L		Jennings *et al.* (1996)
1-chloro-2-nitrobenzene	88-73-3	Oncorhyncus mykiss	89-176		5-36 d	RSD		Niimi *et al.* (1989) in Aquire (5113)
1-chloro-3-nitrobenzene	121-73-3	Oncorhyncus mykiss	77-91		5-36 d	RSD		Niimi *et al.* (1989) in Aquire (5113)
1,2-dichloro-3-nitrobenzene	3209-22-1	Oncorhyncus mykiss	130-153		5-36 d	RSD		Niimi *et al.* (1989) in Aquire (5113)
1,2-dichloro-4-nitrobenzene	99-54-7	Oncorhyncus mykiss	104-130		5-36 d	RSD		Niimi *et al.* (1989) in Aquire (5113)
2,4-dichloro-1-nitrobenzene	611-06-3	Oncorhyncus mykiss	114-126		5-36 d	RSD		Niimi *et al.* (1989) in Aquire (5113)
1,4-dichloro-2-nitrobenzene	89-61-2	Oncorhyncus mykiss	105-120		5-36 d	RSD		Niimi *et al.* (1989) in Aquire (5113)
Toxaphene (m)	8001-35-2	Gambusia affinis	3625		4d	RSD		Andreasen (1985) in Aquire (2178)
		Salvelinus fontinalis, brook trout	67000-76000		29-112 d	RSD		Mehrle and Mayer (1975) in Aquire (877)

A.7 Bioconcentration Data (Continued)

Individual substances	CAS-nr	Species	BCF	Unit	Duration	Exposure conc.	Remarks	References
chlordanes (m)	57-74-9	Pimephales promelas	37800	whole body, ww (?)	32 d	5.9 ug/L	Cont. Flow	Veith *et al.* (1979)
		Cyprinodon variegatus	9000-20000	eggs, whole body	28-189 d	0.5-3.3 ug/L		Parrish *et al.* (1976 and 1978) in Van de Plassche *et al.* (1994)
heptachlor (mixture)		Pimephales promelas	9500	whole body, ww	32 d	3.1 ug/L	Cont. Flow	Veith *et al.* (1979)
		Cyprinodon variegatus	3600	juv.	28 d	?		IPCS, EHC 38 (1984) in Vande Plassche *et al.* (1994)
		Leiostomus xanthurus	4900	whole body	4 d	0.47 ug/L		Schimmel *et al.* (1976) in Van de Plassche *et al.* (1994)
heptachlor	76-44-8	Pimephales promelas	9500	whole body, ww	32 d	3.1 ug/L	Cont. Flow	Veith *et al.* (1979)
		Crassostrea virginica	6300	whole body ww	4 d	430-4300 ug/L		Schimmel *et al.* (1976) in Van de Plassche *et al.* (1994)
heptachlorepoxide	1024-57-3	Pimephales promelas	14000	whole body, ww	32 d	1.3 ug/L	Cont. Flow	Veith *et al.* (1979)
		Mytilus edulis	1700	whole body ww	7 d	0.22 ug/L		Ernst (1977)
tetrachlorobenzyltoluenes (m)	76253-60-6	Poecilia reticulata	47-479	whole body ww	15 d	0.001-0.15 ug/L	static	Van Haelst (1996)
		Dreissena polymorpha	27000 - 150000	whole boy ww	21 d	840-2900 ng/L		Van Haelst (1996)
dimethylphtalate	131-11-3	Lepomis macrochirus	57		1-21 d	RSD		Barrows *et al.* (1980) in Aquire (5175)
diethylphtalate	84-66-2	Lepomis macrochirus	117		1-21 d	RSD		Barrows *et al.* (1980) in Aquire (5175)

A.7 Bioconcentration Data (Continued)

Individual substances	CAS-nr	Species	BCF	Unit	Duration	Exposure conc.	Remarks	References
di-2-ethyl-hexylphtalate	117-81-7	Cyprinodon variegatus, sheepshead minnow	13.50	whole body wet wt.	1 d	500 ug/L, static	sign. biotransformation, metab 3-24 times high than parent comp.	Wofford *et al.* (1981)
		Crassostrea virginica, oyster	11.20	whole body wet wt.	1 d	100 ug/L, static	low biotransf, metab .03-0.1 of parent prod.	Wofford *et al.* (1981)
		Pimephales promelas	155-886	whole body wet wt.	56 d	2-62 ug/L	BCF decr. with exposure conc.	Mehrle and Mayer, 1976
		Rana arvalis, moor frog	appr. 1000	wet wt	60 d	100 ug/L	tadpoles, data read from figure, BSAF ww app. 0.25	Larrson and Thuren (1987)
acridine	260-94-6	Pimephales promelas	125		1d	RSD		Southworth *et al.* (1979a); Aquire 405
quinolin	91-22-5	Pimephales promelas	8		6 d	RSD		Southworth *et al.* (1980) in Aquire (6650)
		Oncorhynchus mykiss	0.002-0.37		1-10 d	RSD		Dauble *et al.* (1987) in Aquire (12712)

A.8 Biomagnification data

Individual substances	CAS-nr	Species	Prey/food species	BMF	Unit	Duration	Exposure conc	Remarks	References
2,2',4,4',5,5'-hexa-bromobiphenyl	59080-40-9	grey seal	herring	140				Derived from field studies	Jansson *et al.* (1993); Pijnenburg *et al.* (1995)
pentachloro-phenol	87-86-5	Anas platyrhyn-chos	commer-cialfeed	0.05	liver wet wt.	11 d	423 mg/kg	at NOAEL, mus-cle lower BMF	Nebeker *et al.*, (1994)
Toxaphene (m)	8001-35-2	Myoxocephalus thompsoni, deep-water sculpin	Mysis relicta	14	dr wt.		mysids: 0.2 mg/kg dr wt, sculpins: 2.6 mg/kg dry wt.	Fieldstudy Lake Michigan, USA	Evans *et al.* (1991)
Oxychlordane	27304-13-8	Herring gull	Alewife	60	?			Fieldstudy Lake Ontario	Braune and Nor-strom (1989); Hoff-man *et al.* (1996)
heptachlor (mix-ture)		Ardeola ralloides, squacco heron	Rana sp.	2.4	dry wt.		frogs: avg 1.5 (n.d. - 3.8) ugkg dry wt., herons: avg 3.4 (n.d.- 6.1) ug/kg dry wt.	Calc. from study Thermaikos Gulf, Greece	Albanis *et al.* (1996)
heptachlo-repoxide	1024-57-3	Herring gull	Alewife	30	?			Fieldstudy Lake Ontario	Braune and Nor-strom (1989)
trans-nonachlor	3734-49-4	Herring gull	Alewife	3	?			Fieldstudy Lake Ontario	Braune and Nor-strom (1989)
cis-nonachlor	29555-47-3	Herring gull	Alewife	5	?			Fieldstudy Lake Ontario	Braune and Nor-strom (1989)
polychlorinated naphtalenes		Phalocrocorax carbo sinensis	marine fish (6 species)	<0.1 - 14	lipid normal-ized		tetra-hepte PCN's, congeners with no vicinal H substitution dominant and BMF > 1		

A.9 Field concentrations fish

Individual substances	CAS-nr	Species	Location	Year	Conc.	Unit	Remarks	References
2,2',4,4',5,5'-hexa-bromobiphenyl	59080-40-9	Coregonus sp., whitefish	Lake Storvindeln, Lapland	1986	0.29	ng/g lw	0.66% lipid	Jansson *et al.* (1993)
tetrabromobi-phenyl-ethers (m)	40088-47-9	Coregonus sp., whitefish	Lake Storvindeln, Lapland	1986	15	ng/g lw	0.66% lipid	Jansson *et al.* (1993)
		Cyprinus Carpio (Carp)	Buffalo River, New York, USA	1991	21.3	ng/g wet wt.	12-19 for small and intermediate size	Loganathan *et al.* (1995)
pentabromobi-phenyl-ethers (m)	32534-81-9	Coregonus sp., whitefish	Lake Storvindeln, Lapland	1986	11.1	ng/g lw	0.66% lipid	Jansson *et al.* (1993)
		Cyprinus Carpio (Carp)	Buffalo River, New York, USA	1991	1.17	ng/g wet wt.	0.6-0.7 for small and intermediate size	Loganathan *et al.* (1995)
		freshwater fish	Rivers, Germany	<1988	0.6 - 120	ng/g lw	35 samples, 18 species	Krüger *et al.* (1988); IPCS (1994)
2,4,5-trichlorophenol	95-95-4	Coregonus sp., whitefish	Lake Storvindeln, Lapland	1986	< 140	ng/g lw	0.66% lipid	Jansson *et al.* (1993)
2,4,6-trichlorophenol	88-06-2	Coregonus sp., whitefish	Lake Storvindeln, Lapland	1986	< 110	ng/g lw	0.66% lipid	Jansson *et al.* (1993)
		Trachurus novaezelandiae, fish	Coast of Sydney (Australia)	1993	< 0.5	ng/g ww	in vicinity of emissions	Jennings *et al.* (1996)
		Esox Lucius	Lakes Finland, Konnevesi, Paijanne, Vatia	<1980	1-18	ng/kg ww	3 Lakes	Paasvirta *et al.* (1980); IPCS (1989)
		Esox Lucius	Lake Finland	<1980	27-40	ng/kg ww	lake in vicinity op pulp mill effluent; 400-500 ng/kg lw	Landner *et al.*(1977) in IPCS (1989

A.9 Fieldconcentrations fish (continued)

Individual substances	CAS-nr	Species	Location	Year	Conc.	Unit	Remarks	References
pentachloro-phenol	87-86-5	Coregonus sp., white-fish	Lake Storvindeln, Lapland	1986	< 97	ng/g lw	0.66% lipid	Jansson *et al.* (1993)
		Trachurus novaezelan-diae, fish	Coast of Sydney (Australia)	1993	< 0.5	ng/g ww	in vicinity of emissions	Jennings *et al.* (1996)
toxaphene (m)	8001-35-2	Coregonus sp., white-fish	Lake Storvindeln, Lapland	1986	ND	ng/g lw	0.66% lipid, det.lim. un-specified	Jansson *et al.* (1993)
		Salvelinus namaycush, lake trout	Great Lakes (USA)	1992-1994	0.13-6.7	mg/kg ww	9-19% lipid	Glassmeyer *et al.* (1996)
toxaphene (m)	8001-35-2	Cichlasoma mana-guense and Sarothero-don mossambicus	Lake Xolothha/n, Nicaragua	1991	40-105	ng/kg ww	range of mean per spe-cies at 4 locations.	Calero *et al.* (1993)
		Gadus Morhua (cod - liver)	Central and Soutehrn N. Sea	1990-1992	65 - 140	ng/kg ww	lipid 42 - 59 %	De Boer and Wester (1993)
		Anguilla sp.	Great Lakes, USA	<1993	133	ng/g ww	mean of 3 locations, lipid 13 +/- 1 %, 12 other fish species. in study)	Newsome and Andrews (1993)
		Lota lota, burbot	8 remote lakes and rivers Canada	1985-1986	810 - 2340	ng/g lw	liver, 20-41% lipid	Muir *et al.* (1990)
		Freshwater fish (53 taxa)	107 lakes, rivers USA	1980-1981	0.27-21	mg/kg ww	geomean-max range, <dl at 12% of stations	Schmitt *et al.*(1985)
chlordanes (m)	57-74-9	Coregonus sp., white-fish	Lake Storvindeln, Lapland	1986	19	ng/g lw	0.66% lipid, as trans-nonachlor, alpha-chlordane < 6, gamma-chlordane <6	Jansson *et al.* (1993)
		perch	Great Lakes (MI, USA)	1990	2.4-26	ng/g ww		Giesy *et al.* (1994)
		Anguilla rostrata	St. Lawrence River, Canada	1990	21 - 48	ng/g ww	sum of 1-chlordane and 2-chlordane	Hodson *et al.* (1993)

A.9 Fieldconcentrations fish (continued)

Individual substances	CAS-nr	Species	Location	Year	Conc.	Unit	Remarks	References
		Fish species (4)	5 remote lakes and rivers N. America	<1978 - 1988	< 10 - 1063	ng/g lw	reviewed in	Muir *et al.* (1990)
		Anguilla sp.	Great Lakes, USA	<1993	28	ng/g ww	mean of 3 locations, lipid 13 +/- 1 %, 12 other fish species in study)	Newsome and Andrews (1993)
		Lota lota, burbot	8 remote lakes and rivers Canada	1985-1986	140 - 380	ng/g lw	liver, 20-41% lipid	Muir *et al.* (1990)
oxychlordane	27304-13-8	Anguilla rostrata	St. Lawrence River, Canada	1990	5 - 14	ng/g ww		Hodson *et al.* (1993)
		perch	Great Lakes (MI, USA)	1990	0.6-3.1	ng/g ww		Giesy *et al.* (1994)
heptachlor (mixture)		Coregonus sp., whitefish	Lake Storvindeln, Lapland	1986	< 60	ng/g lw	0.66% lipid, incl. hepta-chlorepoxide	Jansson *et al.* (1993)
		perch	Great Lakes (MI, USA)	1990	<0.1	ng/g ww		Giesy *et al.* (1994)
		O. mossambicus	Olifants River, South Africa	1990	1	ng/g ww		Grobler (1994)
heptachlor	76-44-8	Anguilla rostrata	St. Lawrence River, Canada	1990	<1 - 1	ng/g ww		Hodson *et al.* (1993)
		Fish (various sp.)	Maryat Lake, Egypt	1990	0.1 - 0.2	ng/g dw	0.2-0.5%lipid	Abd-Allah and Ali (1993)
		Anguilla sp.	Great Lakes, USA	<1993	ND (<0.2)	ng/g ww	mean of 3 locations, lipid 13 %, 12 fish species.	Newsome and Andrews (1993)
		freshwater fish, 6 species: eel, tench, bleak, chub, common carp, black bullhead	4 rivers South Italy (Volturno, Garigliano, Calorem Sele)	1986	ND - 20	ng/g ww	muscle, present in 21-78% of samples	Arnodio-Cocchieri and Arnese (1988)

A.9 Fieldconcentrations fish (continued)

Individual sub-stances	CAS-nr	Species	Location	Year	Conc.	Unit	Remarks	References
heptachlorepoxide	1024-57-3	Anguilla rostrata	St. Lawrence River, Canada	1990	8 - 21	ng/g ww		Hodson *et al.* (1993)
		freshwater fish, 6 species: eel, tench, bleak, chub, common carp and black bull-head	4 rivers South Italy (Volturno, Garigli-ano, Calorem Sele)	1986	5 16	ng/g ww	muscle, present in 100% of samples	Arnodio-Cocchieri and Arnese (1988)
penta-chlorothioanisol	1825-19-0	Catfish	USA	<1984	<0.02	mg/kg ww.	commercial fish	Gardner and Abramovitch (1984)
		Anguilla anguilla	Rijkswateren NL	1978-1982	7-450	ng/g ww	41 locaties, Bovenmerwede 450 ng/g	De Boer (1983)
chloroterphenyls	61788-33-8	Anguilla anguilla	Baltic Sea	<1978	0.08	mg/kg ww.		Renberg *et al.* (1978) in Jensen and Jo/rgensen (1983)
		Anguilla anguilla	Ijsselmeer	<1973	0.4	mg/kg lw		Freudenthal and Greve (1973) in Jensen and Jør-gensen (1983)
		Fish (unsp.)	Japan Sea	<1979	0.01	mg/kg ww	n=30	Takai *et al.* (1979) in Jen-sen and Jo/rgensen (1983)
		Fundulus heteroclitus	Tabbs Creek, Chesa-peake Bay, USA	1989	<0.1 - 6.9	mg/kg dr. wt.		Gallagher *et al.* (1993)

A.9 Fieldconcentrations fish (continued)

Individual sub-stances	CAS-nr	Species	Location	Year	Conc.	Unit	Remarks	References
tetrachlorobenzyl-toluenes (m)	76253-60-6	Fish (various sp.)	Lippe, Uentrop (Germany)	1987	< 0.3	mg/kg lw	no mining act.	Friege *et al.* (1989)
		Fish (various sp.)	Lippe, km 25-135 (Germany)	1987	< 0.3 - 35	mg/kg lw	infl by mining act.	Friege *et al.* (1989)
		Fish (various sp.)	Rhine, Wesel (Germany)	1987	0.8-33	mg/kg lw	infl by Lippe	Friege *et al.* (1989)
		Fish (various sp.)	Ruhr (Germany)	1987	61-110	mg/kg lw	infl by Lippe	Friege *et al.* (1989)
diethylphtalate	84-66-2	Clupea harengus harengus	Gulf St. Lawrence (Canada)	1978	4.7	mg/kg ww.	DHP 17 mg/kg	Musial *et al.* (1981)
		Scomber scombrus, mackerel	Gulf St. Lawrence (Canada)	1978	6.5	mg/kg ww.	DHP 27 mg/kg	Musial *et al.* (1981)
di-2-ethyl-hexylphtalate	117-81-7	Fish (unspec)	Gulf of Mexico (USA)	<1973	0.045	ng/g lw		Zitko (1973) in Wams (1987)
		Eel	Gulf St. Lawrence	<1980	370	ng/kg ww	levels in other fish: mackerel 6500, her-ring 7200, plaice < 1	Musial and Uthe (1980) in IPCS (1992)
		Roach	Finland, near disharge	<1978	ND - 1100	ng/kg ww	near DEHP-factory; pike liver: 2300 ng/kg; invertebrates 100 ng/kg	Persson *et al.* (1978) in IPCS (1992)
		Fish, various species	Japan, rivers seas	1974	10 - 19000	ng/kg ww	results from large survey	Environment Agency Japan (1989) in IPCS (1992)

A.10 Field concentrations invertebrates

Individual substances	CAS-nr	Species-1	Location	Year	Conc	Unit	Remark	References
2,2',4,5'-tetra-bromobiphenyl	60044-24-8	M. edulis	Osaka Bay (Japan)	1987	15	ng/kg ww	tetra-BDE	Watanabe *et al.* (1987): Pijnenburg *et al.* (1995)
2,3,4,6,-tetrachlorophenol		Anadonta piscinalis	Lakes Finland, Konnevesi, Paijanne, Vatia	< 1980	3 - 7	ng/kg ww		Paasvirta *et al.* (1980) in IPCS (1989)
		M. Edulis	Danish Coast	< 1986	0.2 - 3	ng/kg ww		Folke and Birklund (1986) in IPCS (1989)
pentachlorophenol	87-86-5	M. edulis	Coast of Sydney (Australia)	1993	< 0.5	ng/g ww	in vicinity of emissions	Jennings *et al.* (1996)
trichloorfenyl-methaan	27575-78-6	M. edulis	Wadden Sea (NL)	1994	<6	ng/g lw		De Boer *et al.* (1997)
trichloorfenyl-methanol	3010-80-8	M. edulis	Wadden Sea (NL)	1994	13	ng/g lw		De Boer *et al.* (1997)
toxaphene (m)	8001-35-2	Amphipods, Anonyx sarsi and Tmetonyx cicada	Canadian Arctic, Axel Heidelberg island	1986-1987	440-1730	ng/g dr.wt.	average values, lipid 29.2 and 20.8% of dr.wt.	Bidleman *et al.* (1989)
chlordanes (m)	57-74-9	Oyster	Gulf of Mexico	1986-1990	15 - 29	ng/g dr.wt	Sum of heptachlor, eptachlorepoxide, a-chlordane, trans-nonachlor. mean annual conc. (n=132 - 147). US-Musslewatch. Range 1990: < 1 - 69 ng/g.	Sericano *et al.* (1993)
		Bivalves various species	US Coast 51 locations	1977-1992	19 - 6	ng/g dr.w	archived samples from Musselwatch program, geomean of 51 locations	Lauenstein (1995)

A.10 Field concentrations invertebrates (continued)

Individual substances	CAS-nr	Species-1	Location	Year	Conc	Unit	Remark	References
		BIvalves various species	Cental and South America, 76 locations	1991-1992	<1 - 10	ng/g drw	Most locations below 10 ng/kg (background level), several 12-150 ng/kg	Sericano *et al.* (1995)
alpha-chlordane		Oyster	Gulf of Mexico	1986-1990	6 - 14	ng/g dr.wt	Mean annual conc. (n=132 - 147). US-Musslewatch	Sericano *et al.* (1993)
		Zooplankton	Ontario, 33 Lakes (Canada)	1986	0.7 - 22	ng/g dr.wt		Taylor *et al.* (1991)
heptachlor (mixture)		Oyster	Gulf of Mexico	1986-1990	2-4	ng/g dr.wt	Sum of heptachlor, eptachlorepoxide. mean annual conc. (n=132 - 147). US-Musslewatch	Sericano *et al.* (1993)
trans-nonachlor	3734-49-4	Oyster	Gulf of Mexico	1986-1990	5-12	ng/g dr.wt	Mean annual conc. (n=132 - 147). US-Musslewatch	Sericano *et al.* (1993)
chloroterphenyls	61788-33-8	Crassostrea virginica (american oyster)	Tabs Creek (USA)	1989	1.9-18	mg/kg dw		Gallagher *et al.* (1993)
di-2-ethyl-hexylphtalate	117-81-7	Clams	Portland, Maine USA	< 1983	nd - 170	ng/kg ww		Ray *et al.* (1983) in IPCS (1992)
		Odonata spp, Asellus spp	Near ind. discharge	< 1986	5 - 14	mg/kg ww	Near ind. discharge	Thuren (1986) in IPCS (1992)
		Invertebrates (unspec.)	Finland, near disharge	< 1978	100	ng/kg ww	near DEHP-factory; pike liver: 2300 ng/kg	Persson *et al.* (1978) in IPCS (1992)

A.11 Diet-based risk levels reported in the literature

Table A.11.1 Evaluation framework for fish-tissue residues proposed by Nendza et al. (1997).

Compound	NOEC-fish ug/L	BCF-fish L/kg ww	CBB ng/g ww	North Sea fish ng/g ww	Risk-ratio
PCP	0.1	400	40	2.8	0.007
HCB	0.05	45000	2250	1.7	0.0008
DDT	0.003	30000	90	22	0.24
HCH	0.02	730	15	7.2	0.49
B[a]P	0.001	5000	5	27	5.4
PCBs	0.003	68000	204	29	0.14
Cd	0.5	540	270	280	1.04
Hg	0.025	14000	350	58	0.17

Table A.11.2 Summary of secondary poisoning assessment data from Romijn et al. (1993) and v/d Plassche et al. (1994) for chlorinated hydrocarbons.

Compound	BCF_{fish} L/kg ww	$BCF_{bivalve}$ L/kg ww	Bird $NOEC_{extr}$ mg/kg diet ww	Mammal $NOEC_{extr}$ mg/kg diet ww
y—HCH	480	200	0.16	2.5
Dieldrin	6700	2200	0.29	0.35
Aldrin	6700	2200	0.005	0.34
Endrin	4300	1800	0.13	0.074
p,p'-DDT	47778	151000	0.21	7.35
PCP	135	88	24.5	5.5
QCB*	5300	2000(c)		0.5
HCB	18000	7000 (c)	0.5	0.07
Quintozene*	240	4100 (c)	10	2.5
Chlordane*	17000	5400	3.3	3
Heptachlor*	5800	6300	0.9	0.6
Heptachlorepoxide*	14000	1700	0.002	0.7
Endosulfan	2800	53	8.1	0.68

* indicative results due to limited number of adequate toxicity data; (c) calculated values.

Table A.11.3 Summary of diet-based critical levels (ng/g wet wt.) of toxic PCBs (expressed as 2,3,7,8-TCDD-equivalent concentrations (TEQ) or as total PCBs), and some other contaminants derivided for field species.

	Species	Parameter	Value	Ref
TCDD-TEQ	Mink	Diet NOAEC reproduction	0.002	Giesy e.a.'94
	Mink	Diet NOAEL reproduction	0.0003	Tillit e.a. '96
	Mink	Diet LOAEL reproduction	0.013	Tillit e.a. '96
	Mink	Diet NOAEC reproduction	0.001 - 0.017	Leonards e.a. '94
	Otter	Diet NOEC Vit-A deficiency	0.0007	Smit e.a. '94
	Seal	Diet NOEC Vit-A, immune status	0.008	Leonards '97[b]
	Bald eagle	Diet NOAEC, egg mortality	0.0004	Giesy e.a.'95
PCBs (total)[a]	Mink	Diet NOAEC reproduction	72	Giesy e.a.'94
	Bald eagle	Diet NOAEC, egg mortality	140	Giesy e.a.'95
Σ7 PCBs[e]	Mink	Diet NOEC reproduction	145 - 399	Leonards e.a.'94
Σ7 PCBs	Otter	Diet NOEC Vit-A deficiency	6	Smit e.a. '96
PCBs (total)	Otter	Diet NOEC Vit-A deficiency	11	Smit e.a. '96
DDT (total)	Mink	Diet NOAEL	100,000	Giesy e.a.'94
	Bald eagle	Diet NOAEC, reproduction	160	Giesy e.a.'95
Dieldrin	Mink	Diet LOEAL mortality	2,500	Giesy e.a.'94[c]
	Bald eagle	Diet NOAEC, egg mortality	14	Giesy e.a.'95
Heptachlor	Mink	Diet LOAEL growth	6,250	Giesy e.a.'94[d]
Methyl-Hg	Mink	Diet NOAEL mortality	50	Giesy e.a.'94
Hg	Bald eagle	Diet NOAEC, egg mortality	500	Giesy e.a.'95

[a] weathered pattern;
[b] calculated in Leonards (1995) from data by Ross (1995) and De Swart (1994);
[c] based on data by Aulerich *et al.* (1970) ;
[d] based on data by Crum *et al.*(1993);
[e] sum of IUPAC congeners no. 28,51,101,118,138,153 and 180.